



## Innovation, Diversity, and the SBIR/STTR Programs: Summary of a Workshop

### DETAILS

---

94 pages | 6 x 9 | PAPERBACK | ISBN 978-0-309-37352-4

### AUTHORS

---

Sujai J. Shivakumar and David E. Dierksheide, Rapporteurs; Committee on Capitalizing on Science, Technology, and Innovation: An Assessment of the Small Business Innovation Research Program--Phase II; Board on Science, Technology, and Economic Policy; Policy and Global Affairs; The National Academies of Sciences, Engineering, and Medicine

BUY THIS BOOK

FIND RELATED TITLES

### Visit the National Academies Press at [NAP.edu](http://NAP.edu) and login or register to get:

---

- Access to free PDF downloads of thousands of scientific reports
- 10% off the price of print titles
- Email or social media notifications of new titles related to your interests
- Special offers and discounts



Distribution, posting, or copying of this PDF is strictly prohibited without written permission of the National Academies Press. (Request Permission) Unless otherwise indicated, all materials in this PDF are copyrighted by the National Academy of Sciences.

Innovation, Diversity,  
and the  
**SBIR/  
STTR** Programs

---

Summary of a Workshop

Sujai J. Shivakumar and David E. Dierksheide, *Rapporteurs*

Committee on Capitalizing on Science, Technology, and Innovation:  
An Assessment of the Small Business Innovation Research Program—  
Phase II

Board on Science, Technology, and Economic Policy

Policy and Global Affairs

*The National Academies of*  
SCIENCES • ENGINEERING • MEDICINE

THE NATIONAL ACADEMIES PRESS

*Washington, DC*

[www.nap.edu](http://www.nap.edu)

**THE NATIONAL ACADEMIES PRESS      500 Fifth Street, NW      Washington, DC 20001**

This activity was supported by Grant No. HQ0034-10-D-0003, DO#1 between the National Academy of Sciences and Department of Defense; Contract/Grant No. NNX07AJ53G between the National Academy of Sciences and the National Aeronautics and Space Administration; and Contract/Grant No. DMI-0221736 between the National Academy of Sciences and the National Science Foundation. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the organizations or agencies that provided support for the project.

International Standard Book Number-13: 978-0-309-37352-4

International Standard Book Number-10: 0-309-37352-2

Additional copies of this report are available for sale from the National Academies Press, 500 Fifth Street, NW, Keck 360, Washington, DC 20001; (800) 624-6242 or (202) 334-3313; <http://www.nap.edu>.

Copyright 2015 by the National Academy of Sciences. All rights reserved.

Printed in the United States of America

Suggested citation: National Academies of Sciences, Engineering, and Medicine. 2015. *Innovation, Diversity, and the SBIR/STTR Programs. Summary of a Workshop*. Washington, DC: The National Academies Press.

## *The National Academies of* SCIENCES • ENGINEERING • MEDICINE

The **National Academy of Sciences** was established in 1863 by an Act of Congress, signed by President Lincoln, as a private, nongovernmental institution to advise the nation on issues related to science and technology. Members are elected by their peers for outstanding contributions to research. Dr. Ralph J. Cicerone is president.

The **National Academy of Engineering** was established in 1964 under the charter of the National Academy of Sciences to bring the practices of engineering to advising the nation. Members are elected by their peers for extraordinary contributions to engineering. Dr. C. D. Mote, Jr., is president.

The **National Academy of Medicine** (formerly the Institute of Medicine) was established in 1970 under the charter of the National Academy of Sciences to advise the nation on medical and health issues. Members are elected by their peers for distinguished contributions to medicine and health. Dr. Victor J. Dzau is president.

The three Academies work together as the **National Academies of Sciences, Engineering, and Medicine** to provide independent, objective analysis and advice to the nation and conduct other activities to solve complex problems and inform public policy decisions. The Academies also encourage education and research, recognize outstanding contributions to knowledge, and increase public understanding in matters of science, engineering, and medicine.

Learn more about the **National Academies of Sciences, Engineering, and Medicine** at [www.national-academies.org](http://www.national-academies.org).



**Committee on Capitalizing on Science, Technology, and Innovation:  
An Assessment of the Small Business Innovation Research Program—  
Phase II**

**Jacques S. Gansler (NAE), *Chair***

Roger C. Lipitz Chair in Public Policy and Private Enterprise  
Director of the Center for Public Policy and Private Enterprise  
School of Public Policy  
University of Maryland

**David Audretsch**

Distinguished Professor  
Ameritech Chair of Economic  
Development  
Director of the Institute for  
Development Strategies  
Indiana University

**Gene Banucci**

Executive Chairman, ret.  
ATMI, Inc.  
(*Member: 6/26/2009-4/23/2014*)

**Thomas J. Bond**

Grant and Proposal Director  
Association for Manufacturing  
Technology  
(*Member: 6/26/2009-5/21/2014*)

**Michael Borrus**

Founding General Partner  
XSeed Capital\*

**J. Michael Brick**

Vice President and Co-Director of  
Survey Methods  
Westat

**Gail H. Cassell (NAM)**

Senior Lecturer  
Department of Global Health and  
Social Medicine  
Harvard Medical School

**M. Christina Gabriel**

President  
University Energy Partnership  
**Charles E. Kolb (NAE)**  
President and Chief Executive  
Officer  
Aerodyne Research, Inc.

**Virginia Lesser**

Professor of Statistics  
Department of Statistics  
Director, Survey Research Center  
Oregon State University

**Henry Linsert, Jr.**

Chairman and CEO  
Columbia Biosciences Corporation

**W. Clark McFadden II**

Senior Counsel  
Orrick, Herrington & Sutcliffe, LLP

**Duncan T. Moore (NAE)**

Vice Provost for Entrepreneurship  
Rudolf and Hilda Kingslake  
Professor of Optical  
Engineering  
The Institute of Optics  
University of Rochester

---

\*Previously known as X/Seed Capital Management.

**Linda Powers**

Managing Director  
Toucan Capital Corporation  
(Member: 6/26/2009-10/13/2011)

**Donald Siegel**

Dean and Professor  
School of Business  
University at Albany, SUNY

**Jeffrey E. Sohl**

Professor and Director of the Center  
for Venture Research  
Peter T. Paul College of Business and  
Economics  
University of New Hampshire

**Tyrone C. Taylor**

President  
Capitol Advisors on Technology, LLC

**John P. Walsh**

Professor of Public Policy  
School of Public Policy  
Georgia Institute of Technology

**Patrick H. Windham**

Principal  
Technology Policy International

**Project Staff**

**Sujai J. Shivakumar**

Study Director  
(4/1/2014-Current)

**McAlister T. Clabaugh**

Program Officer

**Natacha R. Montgomery**

Senior Program Assistant

**David E. Dierksheide**

Program Officer

**Charles W. Wessner**

Study Director  
(6/26/2009-3/31/2014)

**Karolina E. Konarzewska**

Program Coordinator

For the National Academies of Sciences, Engineering, and Medicine, this project was overseen by the Board on Science, Technology, and Economic Policy (STEP), a standing board established by the National Academies of Sciences and Engineering and the Institute of Medicine in 1991. The mandate of the Board on Science, Technology, and Economic Policy is to advise federal, state, and local governments and inform the public about economic and related public policies to promote the creation, diffusion, and application of new scientific and technical knowledge to enhance the productivity and competitiveness of the U.S. economy and foster economic prosperity for all Americans. The STEP Board and its committees marshal research and the expertise of scholars, industrial managers, investors, and former public officials in a wide range of policy areas that affect the speed and direction of scientific and technological change and their contributions to the growth of the U.S. and global economies. Results are communicated through reports, conferences, workshops, briefings, and electronic media subject to the procedures of the National Academies to ensure their authoritativeness, independence, and objectivity. The members of the STEP Board\* and staff are listed below:

**Richard K. Lester**, *Chair*

Japan Steel Industry Professor and  
Department Head  
Department of Nuclear Science and  
Engineering  
Massachusetts Institute of Technology

**Jeff Bingaman**

Former U.S. Senator, New Mexico  
U.S. Senate

**Ellen R. Dulberger**

Managing Partner  
Dulberger Enterprises, LLC

**Alan M. Garber** (NAM)

Provost  
Harvard University

**Ralph E. Gomory** (NAS/NAE)

Research Professor  
IOMS Department  
Stern School of Business  
New York University

**Michael Greenstone**

The Milton Friedman Professor of  
Economics and the College  
Director, Energy Policy  
Institute at Chicago  
Department of Economics  
The University of Chicago

**John L. Hennessy** (NAS/NAE)

President  
Stanford University

**William H. Janeway**

Managing Director  
Senior Advisor  
Warburg Pincus, LLC

---

\*As of July 2015.



**David T. Morgenthaler**

Founder  
Morgenthaler Ventures

**Luis M. Proenza**

President Emeritus  
University of Akron

**Kathryn L. Shaw**

Ernest C. Arbuckle Professor of  
Economics  
Stanford Graduate School of Business  
Stanford University

**Laura D'Andrea Tyson**

Professor of Business Administration  
and Economics  
Director, Institute for Business &  
Social Impact  
Haas Business & Public Policy Group  
University of California, Berkeley

**Jay Walker**

Chairman  
Patent Properties, Inc.

**STEP Staff**

**Gail E. Cohen**

Director

**Paul T. Beaton**

Senior Program Officer

**McAlister T. Clabaugh**

Program Officer

**Aqila A. Coulthurst**

Associate Program Officer

**Sujai J. Shivakumar**

Senior Program Officer

**David E. Dierksheide**

Program Officer

**Karolina E. Konarzewska**

Program Coordinator

**Natacha R. Montgomery**

Senior Program Assistant

## Preface

At the request of Congress, the National Academies of Sciences, Engineering, and Medicine<sup>1</sup> is reviewing the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs at the Department of Defense, National Institutes of Health, National Aeronautics and Space Administration, Department of Energy, and National Science Foundation.<sup>2</sup> This assessment is the second round of study carried out by the NRC in response to a congressional mandate. The first-round study, carried out by a separate NRC committee, focused exclusively on the SBIR program and resulted in a series of reports from 2004 to 2009.

The SBIR and STTR programs provide federal research and development funding to small businesses. Among the legislative goals of the SBIR program is “to foster and encourage participation by minority and disadvantaged persons in technological innovation.”<sup>3</sup> The committee charged with the assessment of the SBIR and STTR programs convened a workshop on February 7, 2013, that focused on the participation of women, minorities, and both older and younger scientists, engineers, and entrepreneurs in the SBIR and STTR programs, with the goal of reviewing current efforts to expand the pool of SBIR/STTR-funded researchers and of identifying mechanisms for improving participation rates.

---

<sup>1</sup> Effective July 1, 2015, the institution is called the National Academies of Sciences, Engineering, and Medicine. References in this report to the National Research Council are used in an historic context identifying programs prior to July 1.

<sup>2</sup> H.R. 5667, Sec. 108, enacted in Public Law 106-554, as amended by H.R. 1540, Sec. 5137, enacted in Public Law 112-81.

<sup>3</sup> Public Law 97-219, Sec. 2, July 22, 1982, 96 Stat. 217.

Although some time has passed since this workshop was convened, program participation by women and minorities remains a concern, as noted in the committee's recent report on SBIR at the Department of Defense.<sup>4</sup> Because individual participants at the February 2013 workshop made suggestions for addressing this issue, releasing a full summary of the workshop can make an important contribution to the policy dialogue.

This report has been prepared by the workshop rapporteurs as a factual summary of what occurred at the workshop. The committee's role was limited to planning and convening the workshop. The views contained in the report are those of individual workshop participants and do not necessarily represent the views of all workshop participants, the committee, or the Academies.

## ACKNOWLEDGMENTS

On behalf of the National Academies, we express our appreciation and recognition for the insights, experiences, and perspectives made available by the participants of this meeting. Their support and interest were instrumental to the quality and high-level participation of the workshop. Special thanks are also due to McAlister Clabaugh of the STEP staff for his many contributions to the organization of the workshop.

We are also indebted to Catherine Yang for preparing the draft introduction and summary of the meeting.

### Acknowledgment of Reviewers

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the Academies' Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for quality and objectivity. The review comments and draft manuscript remain confidential to protect the integrity of the process.

We wish to thank the following individuals for their review of this report: Tanaga Boozer, United States Patent and Trademark Office; Frank Douglas, Austen BioInnovation Institute; David Finifter, College of William & Mary; Eve Higginbotham, University of Pennsylvania; Jane Muir, University of Florida; and Glendowlyn Thames, Connecticut Innovations.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the content of the report, nor did they see the final draft before its release. The review of this report was

---

<sup>4</sup> National Research Council, *SBIR at the Department of Defense*, Washington, DC: The National Academies Press, 2014.

overseen by Trevor Jones, International Development Corp. Appointed by the Academies, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the rapporteurs and the institution.

Sujai J. Shivakumar

David E. Dierksheide



# Contents

1	INTRODUCTION	1
2	MOVING FORWARD: FINDING SOLUTIONS	9
3	OPENING REMARKS: DEFINING THE ISSUE	15
4	WOMEN AND THE SBIR PROGRAM	21
5	PROFILES OF SCIENTISTS AND ENGINEERS AND AN AGING WORKFORCE	25
6	SBIR/STTR AND SUPPORT FOR SOCIALLY AND ECONOMICALLY DISADVANTAGED SCIENTISTS AND ENGINEERS	29
7	CASES OF SUCCESSFUL HIGH-TECH ENTREPRENEURSHIP	35
8	ROUNDTABLE DISCUSSION	41

APPENDIXES

A	AGENDA	47
B	PARTICIPANTS LIST	51
C	DATA ON WOMAN AND MINORITY PARTICIPATION IN THE SBIR PROGRAM AT THE DEPARTMENT OF DEFENSE	55
D	BIBLIOGRAPHY	67

# 1

## Introduction

The United States' ability to break frontiers in science and technology, creating new products, services, and entire industries along the way, is an important driver of its economic growth. The technology revolution has propelled U.S. productivity,<sup>1</sup> as industries across the board have absorbed advances in information, materials, biological, and other sciences to create whole new markets—from social media and mobile communications to alternative energy and personalized medicine—all transforming the possibilities of human life. In a globalized economy, where other countries are quickly ascending the economic value chain and competition in knowledge-intensive industries becomes more acute, America's aptitude for innovation is all the more prized as a bedrock comparative advantage.

Multiple ingredients fuel the United States' innovation machine. They include university education that fosters critical thinking, government-funded research, public-private sector collaboration, deep capital markets, established rule of law, cultural acceptance of risk-taking, and a comparably hospitable climate for new business formation. A system that endeavors to cultivate the best ideas and talent, whether from small startups or individuals of varied backgrounds, the United States draws strength from the ability to tap all sources of innovation across the economy. Small, rather than large, businesses, often introduce the radical ideas that can transform industries and markets,<sup>2</sup> as the global successes of one-time startups Apple and Google demonstrate today. Similarly, mobilizing all skilled individuals, regardless of race/ethnicity or gender, strengthens the economy and the nation.

---

<sup>1</sup> Dale W. Jorgenson, et al., *Productivity: Information Technology and the American Growth Resurgence*, Cambridge, MA: MIT Press, 2005.

<sup>2</sup> *On the Road to an Entrepreneurial Economy: A Research and Policy Guide, Version 2.0*, Kansas City, MO: Ewing Marion Kauffman Foundation, July 2007, p. 4.



## THE ROLE OF THE SBIR AND STTR PROGRAMS

When Congress established the Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) program, it recognized the contribution of small businesses to U.S. innovation. Congress created the SBIR program in the 1982 Small Business Innovation Development Act to foster technological innovation by encouraging small businesses to meet the nation's research and development (R&D) needs. In 1992, Congress established the STTR program to stimulate technological innovation by facilitating the transfer of federal research to small businesses for commercialization.

The SBIR program provided \$26.9 billion to small businesses through fiscal year (FY) 2009 to support the development of their technologies.<sup>3</sup> In 2011, Congress reauthorized the SBIR and the STTR programs for another 6 years. Federal agencies with extramural R&D budgets over \$100 million continue to allocate a percentage of that budget annually for the two programs.<sup>4</sup> Under the reauthorization, agency allocations for the SBIR program will rise annually from 2.6 percent in FY 2012 to reach 3.2 percent in FY 2017. Agency allocations for the STTR program will rise from 0.35 percent to 0.45 percent over this same period. A pilot program now enables agencies to use 3 percent of their SBIR funds to improve the SBIR or STTR programs' administration, which can include allocating funds for new outreach activities.<sup>5</sup>

As mandated by Congress, the SBIR program continues to carry out four goals: To stimulate technological innovation; use small business to meet federal R&D needs; foster and encourage participation in innovation and entrepreneurship by minority and disadvantaged persons; and increase private-sector commercialization of innovations derived from federal R&D funding.<sup>6</sup> The STTR's goals are to stimulate technological innovation; foster technology transfer through cooperative R&D between small businesses and research institutions; and increase private-sector commercialization of innovations derived from federal R&D.<sup>7</sup>

---

<sup>3</sup> U.S. Small Business Administration, *SBIR*, <http://www.sbir.gov/about/about-sbir>. Accessed March 6, 2013.

<sup>4</sup> Today, 11 agencies participate in the program, including the Department of Agriculture, Department of Commerce, Department of Defense, Department of Education, Department of Energy, Department of Health and Human Services, Department of Homeland Security, Department of Transportation, Environmental Protection Agency, National Aeronautics and Space Administration, and the National Science Foundation.

<sup>5</sup> SBIR/STTR Reauthorization Act of 2011 (U.S. Congress, Public Law 112-81).

<sup>6</sup> These congressional objectives are found in the Small Business Innovation Development Act (Public Law 97-219). In reauthorizing the program in 1992 (Public Law 102-564), Congress expanded the purposes to emphasize the program's goal of increasing private sector commercialization development through federal research and development and to improve the federal government's dissemination of information concerning small business innovation, particularly with regard to woman-owned business concerns and by socially and economically disadvantaged small business concerns.

<sup>7</sup> U.S. Small Business Administration, *STTR/SBIR*, <http://www.sbir.gov/about/about-sttr>. Accessed March 20, 2013.

The SBIR program disburses Phase I awards (grants or contracts) to establish the technical merit and commercial potential of awardees' projects and Phase II awards, based on Phase I results, to support a continuation of awardees' R&D.<sup>8</sup> Phase III companies do not receive SBIR funds but obtain funding from the private sector and/or federal agencies to pursue commercialization for use by the U.S. government.<sup>9</sup> The STTR program follows a similar Phase I to III pathway.<sup>10</sup>

## **NATIONAL RESEARCH COUNCIL STUDY OF THE SBIR AND STTR PROGRAMS**

At the request of Congress, the Board on Science, Technology, and Economic Policy is reviewing the SBIR and STTR programs at the Department of Defense (DoD), National Institutes of Health (NIH), National Aeronautics and Space Administration (NASA), Department of Energy (DoE), and National Science Foundation (NSF). This assessment is the second round of study carried out by the NRC in response to a congressional mandate.<sup>11</sup> The first-round study, carried out by a separate NRC committee, focused exclusively on the SBIR program and resulted in a series of reports from 2004 to 2009. The statement of task for the overall study, to which the current workshop summary contributes partially, appears in Box 1-1.

## **WORKSHOP ON DIVERSITY IN THE SBIR/STTR PROGRAMS**

On February 7, 2013, the committee convened a workshop titled "Innovation, Diversity, and Success in the SBIR/STTR Programs" to examine the participation of women, minorities, and other underrepresented groups in the SBIR/STTR programs and identify ways to increase that participation. The workshop examined both broad demographic trends in the science and engineering workforce and the need for more female and minority representation within that workforce, as well as pragmatic solutions to boost SBIR awards to women and minorities. The statement of task for the workshop appears in Box 1-2.

## **THE WORKSHOP SUMMARY REPORT**

Although some time has passed since this workshop was convened, program participation by women and minorities remains a concern, and releasing a full

---

<sup>8</sup> U.S. Small Business Administration, *SBIR*, <http://www.sbir.gov/about/about-sbir>. Accessed March 20, 2013.

<sup>9</sup> *Ibid.*

<sup>10</sup> U.S. Small Business Administration, *STTR/SBIR*, <http://www.sbir.gov/about/about-str>. Accessed March 20, 2013.

<sup>11</sup> H.R. 5667, Sec. 108, enacted in Public Law 106-554, as amended by H.R. 1540, Sec. 5137, enacted in Public Law 112-81.

### **BOX 1-1**

#### **Project Statement of Task**

In accordance with H.R. 5667, Sec. 108, enacted in Public Law 106-554, as amended by H.R. 1540, Sec. 5137, enacted in Public Law 112-81, the National Research Council is to review the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) programs at the Department of Defense, the National Institutes of Health, the National Aeronautics and Space Administration, the Department of Energy, and the National Science Foundation. Building on the outcomes from the Phase I study, this second study is to examine both topics of general policy interest that emerged during the first-phase study and topics of specific interest to individual agencies.

Drawing on the methodology developed in the previous study, an ad hoc committee will issue a revised survey, revisit case studies, and develop additional cases, thereby providing a second snapshot to measure the program's progress against its legislative goals. The committee will prepare one consensus report on the SBIR program at each of the 5 agencies, providing a second review of the operation of the program, analyzing new topics, and identifying accomplishments, emerging challenges, and possible policy solutions. The committee will prepare a consensus report focused on the STTR Program at all five agencies. The agency reports will include agency-specific and program-wide findings on the SBIR and STTR programs to submit to the contracting agencies and the Congress.

Although each agency report will be tailored to the needs of that agency, all reports will, where appropriate:

1. Review institutional initiatives and structural elements contributing to programmatic success, including gap funding mechanisms such as applying Phase II-plus awards more broadly to address agency needs and operations and streamlining the application process.
2. Explore methods to encourage the participation of minorities and women in SBIR and STTR.
3. Identify best practice in university-industry partnering and synergies with the two programs.
4. Document the role of complementary state and federal programs.
5. Assess the efficacy of post-award commercialization programs.

In addition, the committee will convene symposia to gather information on specific topics related to the SBIR/STTR programs overall or specific agency requests with some workshops resulting in individually-authored workshop summaries.

summary of the workshop can make an important contribution to the policy dialogue by capturing participants' suggestions for addressing the participation of women and minorities in the SBIR and STTR programs. Because the SBIR program has a legislative mandate to foster and encourage participation in innovation

**BOX 1-2**  
**Innovation, Diversity, and Success in the SBIR/STTR Programs:**  
**Summary of a Workshop**  
**Statement of Task**

As part of the Academies' study of the Small Business Innovation Research program, this event will focus on participation of women, minorities, and both older and younger scientists, engineers, and entrepreneurs in the SBIR/STTR programs, with the goal of reviewing current efforts to expand the pool of SBIR/STTR-funded researchers and to identify mechanisms for improving participation rates. An individually authored workshop summary will be published based on the workshop.

and entrepreneurship by minority and disadvantaged persons, as noted above, most of the workshop discussion centered on that program.

The remainder of Chapter 1 distills workshop presentations and additional background materials on the current participation of women and minorities in SBIR/STTR programs and the value of a diverse workforce in general. Chapter 2 provides selected suggestions from workshop participants of ways to increase this participation. Chapters 3-8 summarize the individual workshop presentations and discussions. The workshop agenda, listing the speakers and their presentations, is found in Appendix A, and a full list of participants is found in Appendix B. Appendix C includes data on woman and minority participation excerpted from the committee's report on the SBIR program at the Department of Defense,<sup>12</sup> and Appendix D includes a reference bibliography.

**THE NATIONAL NEED FOR A DIVERSE SCIENCE  
AND ENGINEERING WORKFORCE**

A leading theme during the workshop was the importance of woman and minority participation in U.S. science and technology, and overall, the need to continue to fill the U.S. pipeline with well-trained scientists and engineers.<sup>13</sup> U.S. science and engineering workforce needs are projected to grow faster than those of any other sector, according to the U.S. Bureau of Labor Statistics.<sup>14</sup>

---

<sup>12</sup> National Research Council, *SBIR at the Department of Defense*, Washington, DC: The National Academies Press, 2014.

<sup>13</sup> See also National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Rising Above the Gathering Storm—Energizing and Employing America for a Brighter Economic Future*, Washington, DC: The National Academies Press, 2007, p. 213.

<sup>14</sup> National Research Council, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*, Washington, DC: The National Academies Press, 2011, p. 36.

The United States lags other nations in attracting its own citizens to enter science and engineering, ranking 20th out of 24 countries in the percentage of 24-year-olds who have earned a first degree in the natural sciences or engineering in 2000.<sup>15</sup> Recent data from the Census Bureau show that the challenge could become more acute, as minority groups, such as Hispanics and African Americans, who have been historically underrepresented in U.S. science and engineering, become a more dominant proportion of the U.S. population. Minorities, including Hispanics, African Americans, and Asian Americans, are the most rapidly growing segments of the population. Altogether, minorities are expected to comprise a majority of the U.S. population by 2043.<sup>16</sup>

Today, women and minorities are notably underweighted in the nation's science and engineering workforce. According to Grace Wang, director of the NSF's Industrial Innovation and Partnerships Division at the time of the workshop, 65 percent of the total U.S. population in 2008 consisted of women, Hispanics, African Americans, Native Americans, and people with disabilities, yet these groups constituted only 33 percent of science and engineering occupations, according to 2006 NSF data.<sup>17</sup>

The 2011 publication by the National Research Council, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at a Crossroads*, notes that underrepresented minorities, defined as Hispanics, African Americans, Native Americans/Alaska Natives, comprise a small percentage at each step of the science, technology, engineering, and mathematics (STEM) education process.<sup>18</sup> The percentages of African Americans and Hispanics interested in STEM undergraduate majors are similar to those of white and Asian Americans, but their completion rates are much lower.<sup>19</sup> At the graduate school level for science and engineering, underrepresented minorities receive only 14.6 percent of master's degrees and 5.4 percent of doctoral degrees.<sup>20</sup> Data from the National Science Board indicate that women earn roughly half of S&E degrees at the bachelor's, master's, and PhD levels, but they earn "fewer than one-third of the doctorates awarded in physical sciences, mathematics and computer sciences, and engineering" and less than one-quarter of engineering master's degrees.<sup>21</sup>

---

<sup>15</sup> Ibid, p. 35.

<sup>16</sup> U.S. Census Bureau, *U.S. Census Bureau Projections Show a Slower Growing, Older, More Diverse Nation a Half Century from Now*, <https://www.census.gov/newsroom/releases/archives/population/cb12-243.html>. Accessed February 23, 2015.

<sup>17</sup> See presentation by Grace Wang, National Science Foundation, in Chapter 6 of this volume.

<sup>18</sup> National Research Council, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*, Washington, DC: The National Academies Press, 2011, pp. 37-38.

<sup>19</sup> Ibid, pp. 38-39.

<sup>20</sup> Ibid, p. 38. Here, underrepresented minorities are also defined as African Americans, Hispanics, and Native Americans/Alaska Natives.

<sup>21</sup> National Science Board, *Science and Engineering Indicators 2014*, Arlington, VA: National Science Foundation, 2014, pp. 2-26, 2-29, 2-32, and appendix table 2-29.

## PARTICIPATION BY WOMEN AND MINORITIES IN THE SBIR AND STTR PROGRAMS

According to the U.S. Small Business Administration (SBA), SBIR awards to women and minorities fall far short of their representation in the potential applicant pool, measured against those owning businesses and those who are STEM graduates. In his workshop remarks, Winslow Sargeant of the SBA pointed out that woman- and minority-owned small businesses receive less than 16 percent of all SBIR awards. Of that, he said, 6 percent go to woman-owned firms, and less than 10 percent go to minority-owned firms. In contrast, women comprise 51 percent of the U.S. population and 27 percent of STEM graduates. Together, Hispanics, African Americans, Asian Americans, and Native Americans constitute 36 percent of the U.S. population and 26 percent of STEM graduates.<sup>22</sup>

Agency data reported at the workshop underscore the challenge. Sally Rockey of the National Institutes of Health (NIH) reported that only about 27 percent of NIH grants support female researchers, whereas 55 percent of biomedical department students and trainees are women. She also reported that only 2-3 percent of NIH grants' principal investigators are minorities.<sup>23</sup>

Data collected as part of the committee's study of the DoD SBIR program,<sup>24</sup> published after the workshop was held, further illustrate the problem: the committee found participation in the DoD SBIR program among women and minorities to be "low and not increasing" and recommended several actions (see Box 1-3). Selected data excerpted from that report are included in Appendix C of the present volume.

## THE VALUE OF DIVERSITY IN INNOVATION

While greater participation of women and minorities in U.S. science and engineering can help to ensure a stable pipeline of talent to weather U.S. demographic and global economic shifts, workshop speakers noted how the addition of women and minorities enriches America's science and technology innovation in a more qualitative manner. For example, Peggy Wallace of Golden Seeds noted that research shows companies with women on their boards to be more profitable than other companies.<sup>25</sup>

Personal experiences shared during the National Academies' workshop suggest that the blending of multiple viewpoints often does cast a new lens on old problems, leading to innovative solutions. Eric Adolphe of CenterScope

---

<sup>22</sup> These statistics were presented by Winslow Sargeant of the Small Business Administration. The breakdown of SBIR awards by ethnic group is not available in this set of statistics. See presentation in Chapter 3 of this volume.

<sup>23</sup> See presentation by Sally Rockey, National Institutes of Health, in Chapter 5 of this volume.

<sup>24</sup> National Research Council, *SBIR at the Department of Defense*, Washington, DC: The National Academies Press, 2014.

<sup>25</sup> See presentation by Peggy Wallace, Golden Seeds, in Chapter 4 of this volume.

**BOX 1-3**  
**Findings and Recommendations Relating to**  
**Participation of Women and Minorities:**  
**Excerpt from *SBIR at the Department of Defense***

**Current participation of women and other under-represented groups in the SBIR program is low and not increasing.**

- During the study period,<sup>a</sup> approximately 15 percent of awards went to woman-owned small businesses (WOSB) and 7 percent to minority-owned small businesses (MOSB).
- The NRC survey indicated that black- and Hispanic-owned small businesses are themselves a very small share of MOSB overall. Black-owned small businesses accounted for approximately 0.5 percent of all respondents; Hispanic-owned firms, about 1 percent.
- DoD has not made sustained efforts to “foster and encourage” the participation of woman- and minority-owned small businesses.

**Addressing Under-Represented Populations**

- **No Quotas:** DoD should *not* develop quotas for the inclusion of selected populations into the SBIR program. Such an approach is not necessary to meet congressional intent and is likely to reduce program effectiveness.
- **Outreach and Education:** DoD should develop an outreach and education program focused on expanding participation of under-represented populations.
- **Tracking and Metrics:** The DoD Office of Small Business (OSB) should improve tracking and metrics against which to benchmark the activities of components in relation to this congressional objective.

---

<sup>a</sup> FY2002-FY2011, inclusive.

SOURCE: Excerpted from pp. 2-4 of Summary chapter of National Research Council, *SBIR at the Department of Defense*, Washington, DC: The National Academies Press, 2014. The committee's full findings and recommendations relating to the participation of women and minorities in the DoD SBIR program can be found on pp. 207-209 and pp. 223-225 of that report.

Technologies, who is a 17-time SBIR awardee, credited the diversity of his team for his first SBIR award.<sup>26</sup> He described the experience of writing code overnight for a NASA Phase II award. His diverse team not only won the award but also garnered the NASA SBIR of the Year Award. “We were able to solve complex problems because we all thought differently,” he said.

---

<sup>26</sup> See presentation by Eric Adolphe, CenterScope Technologies, in Chapter 6 of this volume.

## 2

# Moving Forward: Finding Solutions

Obstacles facing underrepresented groups are broad-ranging. SBIR challenges include attracting and retaining female and minority students in science and engineering, removing barriers specific to the Small Business Innovation Research (SBIR) program's award process, providing entrepreneurship training, and lowering obstacles in startups' transition from research and development to commercial viability.

Personal stories shared by SBIR entrepreneurs illustrate the extent to which many among underrepresented groups lack the access, connections, experience, and nontechnical skills that propel others forward. Getting the encouragement, information, training, and financial support at the right time during their careers can spell the stark difference between success and failure.

Individual workshop participants made a number of suggestions for addressing the participation of women and minorities in the SBIR and Small Business Technology Transfer (STTR) programs. These suggestions spanned a wide range but broadly fell within three categories—expanding the pool of applicants, eliminating barriers in award applications and selection, and providing greater education and support for entrepreneurship training and commercialization efforts. The suggestions made here are those of individual workshop participants and do not necessarily represent the views of the workshop participants as a whole, the committee, or the National Academies of Sciences, Engineering, and Medicine.



## EXPANDING THE POOL OF APPLICANTS: INCREASING THE PIPELINE AND IMPROVING OUTREACH

Expanding the pipeline of woman and minority applicants to the SBIR program is the foundation to improving SBIR diversity results. Suggestions included the following:

- *Focus on the pipeline of talented women and minorities to upgrade diversity performance.* “We need to increase the pipeline and stop leakage of the pipeline,” said the National Science Foundation’s (NSF) Grace Wang. She indicated that NSF is working on increasing the number of applications to the program.<sup>1</sup>
- *Encourage more women and minorities to enter and stay in science and engineering.* ML Mackey of Beacon Interactive Systems stressed the importance of showing that science and engineering is a creative field—that it can be used to solve real-life problems.<sup>2</sup> Jagannathan Sankar of North Carolina A&T University provides student researchers at this historically black university with opportunities at his NSF Engineering Research Center. To train them to become next-generation global innovation leaders, he provides exchange and travel programs for students to engage with researchers in Germany and Asia, while enabling them to work on cutting-edge research at home.<sup>3</sup>
- *Provide students, teachers, community college and Minority-Serving Institution (MSI) faculty, veterans, and others, an opportunity to work with SBIR companies to learn about R&D work and to gain entrepreneurial skills.*<sup>4</sup> NSF awards Phase II SBIR companies extra funds if they hire such candidates. The programs include, among others, Research Assistantships for High School Students; Research Experience for Teachers, enabling teachers to take the culture of innovation and entrepreneurship back to the classroom; Research Experience for Undergraduates, the most popular program among Phase II awardees; and the Small Business Post-Doc Research Diversity Fellowship, enabling postdocs to work for Phase II companies for up to \$75,000 each.

A theme that ran throughout the workshop was a need to conduct more effective outreach to potential applicants in order to encourage participation among underrepresented groups. Suggestions included the following:

---

<sup>1</sup> See presentation and remarks by Grace Wang, National Science Foundation, in Chapter 6 of this volume.

<sup>2</sup> See presentation by ML Mackey, Beacon Interactive Systems, in Chapter 7 of this volume.

<sup>3</sup> See presentation by Jagannathan Sankar, North Carolina A&T University, in Chapter 6 of this volume.

<sup>4</sup> See presentation by Grace Wang, National Science Foundation, in Chapter 6 of this volume.

- *Improve outreach not by starting new initiatives from scratch, but by partnering with existing networks serving disadvantaged populations.*<sup>5</sup> Partner organizations could include the Society of Women Entrepreneurs, Society of Women Engineers, Society of Hispanic Professional Engineers, Historically Black Colleges and Universities (HBCUs), MSIs, Small Business Development Centers, the National Business Incubators Association, and the Association of University Technology Managers.
- *Maintain a central database of potential outreach partners in the Small Business Administration, including nonprofits and state and local development institutions.*<sup>6</sup>
- *Repeat the same outreach events multiple times to see how interest grows.*<sup>7</sup>
- *Use the 3 percent of SBIR budgets for program management to improve outreach and reduce barriers to completing applications.*<sup>8</sup>
- *Find more creative ways to reach out to potential applicants early in their academic or business careers.* Some workshop speakers learned about the SBIR program by accident.<sup>9</sup>

### **ELIMINATING BARRIERS IN AWARD APPLICATIONS AND SELECTION**

Even an abundant pipeline and successful outreach will not increase SBIR diversity if applications from woman and minority candidates are not deemed competitive enough to win either a Phase I award or to transition successfully from Phase I to Phase II. According to the workshop discussion, the SBIR program's application process presents a significant hurdle; cracking the code on producing a winning application is not straightforward. Suggestions on this topic included the following:

- *Institute a Phase Zero program at the federal level, like those in Florida, Vermont, and other states, awarding applicants funds to hire consultants to help prepare stronger proposals, including technology development and commercialization strategies.*<sup>10</sup>

---

<sup>5</sup> See presentation by Winslow Sargeant, Small Business Administration, in Chapter 3 of this volume and the presentation of Tanaga Boozer, U.S. Patent and Trademark Office, in Chapter 4 of this volume.

<sup>6</sup> See remarks of Ronald Cooper, Small Business Administration, in Chapter 8 of this volume.

<sup>7</sup> See remarks of Kevin Wheeler, Senate Committee on Small Business and Entrepreneurship, in Chapter 7 of this volume.

<sup>8</sup> *Ibid.*

<sup>9</sup> See presentations by Karina Edmonds, Department of Energy, and Eric Adolphe, CenterScope Technologies, in Chapter 6 of this volume. See also the presentation of ML Mackey, Beacon Interactive Systems, in Chapter 7 of this volume.

<sup>10</sup> See presentation by Tanaga Boozer, U.S. Patent and Trademark Office, in Chapter 4 of this volume.

- *Promote the use of mentors and role models who have won SBIR awards in the past to help SBIR applicants write successful proposals.*<sup>11</sup>
- *Incorporate more women and minorities into the SBIR review panels, particularly representatives from smaller universities.*<sup>12</sup>
- *Conduct blind reviews of the technical merit sections of proposals.*<sup>13</sup>
- *Streamline the selection process.*<sup>14</sup>

## PROVIDING GREATER SUPPORT FOR ENTREPRENEURSHIP TRAINING AND COMMERCIALIZATION EFFORTS

Several speakers noted that program funding agencies can provide entrepreneurship training or can partner with other organizations that provide such training to prepare academically focused researchers for the demands of business. Several such programs exist today and were described at the workshop.

- The NSF's programs awarding SBIR Phase II companies extra funds to hire students, faculty, and veterans provide them exposure to entrepreneurial culture.<sup>15</sup>
- AARP's entrepreneurship workshops for workers ages 59 and over accomplish a similar objective.<sup>16</sup>
- Florida's Empowering Women in Technology Startups (ewits®) program provides women with multi-week training in managing a startup.<sup>17</sup> Each participant is paired with an experienced female mentor and works in virtual company management teams to develop a business plan and investor presentation.<sup>18</sup>

Additional suggestions included the following:

- *Require a one-page commercialization plan for Phase I applications, except for those focused on basic research, to help to focus applicants*

<sup>11</sup> See presentation by Eric Adolphe, CenterScope Technologies, in Chapter 6 of this volume. See also the remarks of Tanaga Boozer, U.S. Patent and Trademark Office (Chapter 4); Grace Wang, National Science Foundation (Chapter 6); ML Mackey, Beacon Interactive Systems (Chapter 7); Jane Muir, University of Florida (Chapter 7); Christopher Rinaldi, Department of Defense (Chapter 8); and Joseph Hennessey, National Science Foundation (Chapter 8).

<sup>12</sup> See remarks of Timothy McClees, House Armed Services Committee, in Chapter 6 of this volume.

<sup>13</sup> See presentation by ML Mackey, Beacon Interactive Systems, in Chapter 7 of this volume.

<sup>14</sup> See presentation by Karina Edmonds, Department of Energy, in Chapter 6 of this volume.

<sup>15</sup> See presentation by Grace Wang, National Science Foundation, in Chapter 6 of this volume.

<sup>16</sup> See presentation by Jeff Makowka, American Association of Retired Persons, in Chapter 5 of this volume.

<sup>17</sup> See presentation by Jane Muir, University of Florida, in Chapter 7 of this volume and comments of Winslow Sargeant, Small Business Administration, in Chapter 3 of this volume, and of Joseph Hennessey, National Science Foundation, in Chapter 8 of this volume.

<sup>18</sup> See presentation by Jane Muir, University of Florida, in Chapter 7 of this volume.

on the next steps in the continuum from research to development to commercialization for their projects.<sup>19</sup>

- *Pair Phase II mentors with Phase I awardees.*
- *Adopt legislative incentives to encourage large companies to outsource to small companies and to protect the intellectual property of small companies, particularly in the Department of Defense procurement sphere.*<sup>20</sup>

In his remarks as moderator of the closing roundtable, NRC SBIR/STTR committee member Michael Borrus of X/Seed Capital Management suggested that different approaches be tested: “The only thing that works is comprehensive attention to the problem itself at all points and a commitment to do that,” adding that we must “remove roadblocks, align incentives, measure the results; rinse and repeat; and do it ‘til you get it right.”<sup>21</sup>

---

<sup>19</sup> See presentation by Tanaga Boozer, U.S. Patent and Trademark Office, in Chapter 4 of this volume.

<sup>20</sup> See presentation by Alison Brown, NAVSYS, in Chapter 7 of this volume.

<sup>21</sup> See remarks of Michael Borrus of X/Seed Capital Management in Chapter 8 of this volume.



### 3

## Opening Remarks: Defining the Issue

The workshop's opening presentations welcomed the participants, framed the purpose of the event, and provided statistical background on the participation of women and minorities, drawing specifically on data on the Small Business Innovation Research (SBIR) program. The chair of the committee, Dr. Jacques Gansler, set the objective of gathering speaker recommendations for enhancing access to the SBIR and Small Business Technology Transfer (STTR) programs by woman- and minority-owned businesses. He noted that the workshop would explore lessons from success stories as well as demographic challenges.

A keynote address by Winslow Sargeant of the Small Business Administration (SBA) Office of Advocacy principally focused on statistics showing that women and minorities are underrepresented in STEM degree attainment, business ownership, and receiving SBIR awards. Dr. Sargeant recommended strengthening outreach efforts, including tapping into existing networks with ties to the woman and minority communities, and he highlighted National Science Foundation (NSF) programs designed to encourage ties between SBIR awardees and underserved schools.<sup>1</sup>

The content of the discussion and issues and recommendations raised by speakers is summarized below.

---

<sup>1</sup> See presentation by Grace Wang, National Science Foundation, in chapter 6 of this volume.

*Charles Wessner*  
*National Research Council*

Charles Wessner, then of the Academies, welcomed participants to the workshop. He invited them to a constructive and forward-looking discussion on realistic approaches to encourage participation by women and minorities in the SBIR and STTR programs.

Dr. Wessner noted that the Academies is currently conducting its second-round assessment of the SBIR program. This examination will follow up on surveys capturing changes in program perceptions, practices, and outcomes to assess the efficacy of post-award commercialization programs, encourage university-industry partnering and synergies, streamline the application and award processes, and examine complementary state and federal programs. At the request of Congress, the board is now also reviewing the STTR program as part of the project.

*Jacques Gansler*  
*University of Maryland*

Jacques Gansler of the University of Maryland, chair of the committee studying the SBIR and STTR programs, introduced the day's proceedings as following in the spirit of innovation. Applying the "idea of continuous product and process improvement" to the SBIR program, he set as the workshop objective the gathering of recommendations for enhancing access to the SBIR program by woman- and minority-owned businesses, one of the program's four congressional mandates. Dr. Gansler said that the workshop would explore SBIR and STTR success stories and lessons as well as and also demographic challenges, including ways to encourage baby boomers and younger entrepreneurs to participate. The day's discussions would form part of an ongoing study of how to solve the challenge of broadening access, he said.

Noting that many countries have tried to emulate the U.S. SBIR program, Dr. Gansler said the challenge now is to maintain focus on the program's long-term objectives amidst current budgetary pressures that may tempt policymakers into "giving up the future for the present." Indeed, a key finding from the first round of the committee's assessment was the SBIR program's success in supporting the growth of woman- and minority-owned businesses.<sup>2</sup> The committee has been collecting data to monitor such outcomes. To improve their ability to reach minorities and women, federal agencies must identify and find ways to overcome obstacles.

---

<sup>2</sup> National Research Council, *An Assessment of the SBIR Program*, Charles W. Wessner, editor, Washington, DC: The National Academies Press, 2008, p. 54.

*Winslow Sargeant*  
*Small Business Administration*

In his keynote address, Winslow Sargeant of the SBA Office of Advocacy discussed the congressionally mandated objectives of the SBIR program, founded in 1981 as a pilot program by the SBA. In 1982, when the Small Business Innovation Development Act expanded the SBIR program into a government-wide program, Congress set four goals: (1) stimulate technological innovation, (2) meet federal research and development needs, (3) foster and encourage participation in innovation and entrepreneurship by socially and economically disadvantaged persons, and (4) increase private-sector commercialization of innovations derived from federal R&D funding.

Dr. Sargeant cited the following statistics, which reveal a shortfall in SBIR awards to women and minorities compared with their representation among U.S. businesses and science, technology, engineering, and mathematics (STEM) graduates:

- Women make up 51 percent of the total U.S. population and 27 percent of STEM graduates. Twenty-nine percent of businesses are woman-owned, and 6 percent of SBIR awardees are woman-owned.
- Hispanics comprise 17 percent of the population and 5 percent of STEM graduates. Eight percent of businesses are Hispanic-owned.
- African Americans comprise 13 percent of the population and 4 percent of STEM graduates. Seven percent of businesses are African American-owned.
- Asian Americans comprise 5 percent of the population and 17 percent of STEM graduates. Six percent of businesses are Asian American-owned.
- Native Americans comprise 1.2 percent of the population and 0.3 percent of STEM graduates. One percent of businesses are Native American-owned.
- Less than 16 percent of SBIR awards go to woman- and minority-owned businesses. Woman-owned businesses comprise 6 percent of SBIR awardees, and businesses owned by all other minorities, which are not disaggregated by ethnicity, comprise less than 10 percent of SBIR awardees.

To do better, Dr. Sargeant said, agencies should conduct greater outreach to these groups using in part the 3 percent funds for program management created in the 2011 SBIR Reauthorization Act. Dr. Sargeant recommended tapping into networks that already serve these groups, rather than creating new programs. Such networks include the Society of Women Entrepreneurs, Society of Women Engineers, Society of Hispanic Professional Engineers, IEEE USA, *nerdgirls.com*, Historically Black Colleges and Universities (HBCUs), Minority-Serving Institutions (MSIs), and tribal colleges.



In addition, Dr. Sargeant highlighted NSF programs, in which SBIR awardees with Phase IA funding can receive additional funding if they partner with an underserved school and in which those that attain Phase IIA funding can receive additional funding if they work with faculty of an MSI.

## DISCUSSION

Karina Edmonds of the Department of Energy suggested public education highlighting the bottom-line benefits of diversity and noted studies that show that companies with diverse boards are more profitable.

Joseph Misanin of the small business office of the Department of Defense suggested setting regional goals. Statutory goals for federal contract awards are set at 5 percent for woman- and minority-owned businesses, he noted. By that measure, the 6 percent of SBIR awards going to women indicates adequate achievement on the national level. But some regions, in contrast, may be lagging and in need of a push. John Williams, then of the U.S. Navy's SBIR program, noted that setting effective goals depends on having better information about the potential applicant pool. Is the number of women and minorities with PhDs who own businesses small in comparison to the number of women and minorities who hold PhDs, for example? If so, then the focus should be on encouraging female and minority PhDs to form companies or companies to appoint women and minorities as principal investigators. At any rate, setting a single federal goal would be helpful, he said. Mr. Misanin suggested that federal data on participation rates of minority-owned federal contractors could be used as a benchmark to compare the number of minority-owned businesses receiving SBIR awards.

Gail Cassell of Harvard Medical School, who is a member of the NRC SBIR/STTR committee, suggested cultivating young female faculty members to start companies. She also suggested forging partnerships between companies and SBIR investigators who want to start companies and promoting collaboration between investigators and other countries with funds to invest. For example, she said, Russia's small grant program is searching for recipients.

Dr. Sargeant noted SBA concerns that young faculty and investigators are not receiving credit toward tenure for their SBIR awards and work.

Heidi Jacobus, founder of SBIR awardee Cybernet Systems, said that diversity in employment at woman-owned businesses is an under-recognized attribute and questioned whether the statistic that women receive 6 percent of SBIR awards is over reported, if awardees choose more than one demographic category.<sup>3</sup>

Robin Gaster of Innovations Competitions, LLC, said he is working with the National Academies to develop a list of potential applicants by state, including

---

<sup>3</sup> The survey administered by the NRC committee studying the SBIR and STTR programs includes separate questions about the woman or minority status of the (1) principal investigator for the award and (2) owner at the time of award.

an Oregon-based project to identify all woman- and minority-owned businesses in that state.

Alison Brown of NAVSYS, an SBIR company, remarked about the transition from Phase II to Phase III commercialization. She noted that once a company wins an SBIR award, it is often easier to win more awards. A company that cannot commercialize its technology has lower chances of winning subsequent awards. Helping woman- and minority-owned companies to commercialize would improve outcomes, she said.

Todd Brethauer asked whether SBIR success rates match submission rates. Because companies that have won SBIR awards have a higher chance of future success, he suggested a two-tier evaluation system, separating applicants who have submitted less than five proposals from those who have submitted more than five proposals.



## 4

# Women and the SBIR Program

Opening the first panel, Christina Gabriel of the University Energy Partnership, who is a member of the Academies Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR) committee, indicated that the focus of the presentations would turn to suggestions on how to address the issues that have been identified. The panel included the recommendations of a female entrepreneur, Tanaga Boozer, now with the Patent and Trademark Office, and of Peggy Wallace, the managing partner of Golden Seeds, an angel and venture funding firm with a mission to empower women. Tanaga Boozer made a number of suggestions including enhancing outreach measures such as targeting woman and minority innovators at research institutions; conducting SBIR workshops at minority entrepreneurship conferences, Minority-Serving Institutions, and Small Business Development Centers; launching a federal Phase Zero program; and developing mentorship programs for Phase II and Phase I grantees. During her presentation, Peggy Wallace highlighted the difficulty that woman-led businesses face in obtaining financing, noting that only 6 percent of companies that secured venture capital in 2010 had female CEOs and that only 7 percent had female founders. She argued for the importance of increasing the number of women serving on corporate boards, indicating that studies have shown that female board membership is associated with better company performance.

The content of the discussion and issues and recommendations raised by speakers is summarized below.

*Tanaga Boozer*  
*U.S. Patent and Trademark Office*

Tanaga Boozer of the U.S. Patent and Trademark Office shared her personal story as an SBIR awardee and recommendations for program improvement. In 2003, she started working as a consultant to Florida A&M University, charged with writing an SBIR grant. She then launched a company to create a Web tool to help others receive technology transfer services and identify commercialization resources such as SBIR funding. Her company won an SBIR award from the National Science Foundation (NSF) in 2006 and a patent for her technology in 2012. After the NSF denied the company's Phase II application, Ms. Boozer began serving as a Department of Defense (DoD) technology transfer reviewer. This, she said, provided her with insights on how applicants can improve their chances of winning SBIR Phase II awards. Others could learn from similar experiences.

Although the SBIR program has, according to Ms. Boozer, succeeded in its first two goals to stimulate innovation and to increase the number of small businesses to meet U.S. research and development (R&D) needs, there is concern about whether SBIR is a research program or a commercialization program. If it is a research program, then it might be appropriate for applicants to receive several Phase I awards to support early research programs and to never seek Phase II funding. If, however, it is a commercialization program, then there should be adequate mechanisms to support an applicant's seamless movement from Phase I to Phase II and better coordination of federal resources for SBIR awardees. Finally, she indicated that the program must improve upon the fourth goal to foster and encourage participation by women and minorities. Enhancing outreach measures such as targeting woman and minority innovators at research institutions; conducting SBIR workshops at minority entrepreneurship conferences, Minority-Serving Institutions, and Small Business Development Centers; launching a federal Phase Zero program, similar to Florida and Vermont state programs; and developing mentorship programs for Phase II and Phase I awardees may be helpful in increasing minority participation.<sup>1</sup>

In addition, Ms. Boozer recommended launching a national advertisement campaign that expressly links federal research programs to America's competitiveness. She noted that it is important to provide context for why the federal government "invests" in research and to highlight how that return on investment is realized as new jobs, new products, and services. Ms. Boozer also suggested that requiring a one-page commercialization or transition plan in "all" research proposals would lead researchers to contemplate the need and the methods for

---

<sup>1</sup>The NRC committee studying the SBIR and STTR programs convened a workshop to learn about the role of state programs in complementing and leveraging the SBIR and STTR programs for regional growth. That event, "SBIR/STTR and the Role of State Programs," was convened on October 7, 2014.

turning research into commercial innovations earlier in the innovation cycle. This, she predicted, would increase the likelihood that researchers are better prepared and encouraged to participate in innovation programs, such as the SBIR program.

*Peggy Wallace  
Golden Seeds*

Peggy Wallace of Golden Seeds indicated that her company operates the country's fourth largest angel group, three venture capital funds, and investments in companies with women at the C-level. Golden Seed's angel investor group is 80 percent female, and its mission is to empower women entrepreneurs. "That's how we're going to change the world," said Ms. Wallace. "We're going to get the female brain into companies." Golden Seed's portfolio includes woman-led SBIR awardees in life sciences and investments with state economic development agencies and inQTel, the CIA's venture capital fund.

Angel and venture capital funders provide \$40-60 billion in financing a year, she noted, according to the National Venture Capital Association and the Center for Venture Research at the University of New Hampshire. Total angel funding is almost as large as venture capital. Angels invest in earlier-stage deals than do venture capitalists, writing average checks of \$300,000 to \$500,000, compared to average venture capital checks of \$500,000 to \$700,000, she said.

About 97 percent of venture capitalists are white males, said Ms. Wallace. In contrast, about 20 percent of startups led by women sought venture capital in 2011, and 13 percent received funding. Women receive about 10 percent of venture capital or angel funding in any given year.<sup>2</sup> When Golden Seeds started, woman-owned businesses received only zero to 3 percent of such funding. In 2010, only 6 percent of companies that received venture capital had female CEOs, 7 percent had female founders, and 10 percent had a female founder or CEO at some point.

Ms. Wallace noted that women hold 17 percent of U.S. board seats. Some European countries have adopted diversity quotas.<sup>3</sup> "That's the only way to make it happen," she said. She cited studies showing that companies with female board members perform better than those without female board members.<sup>4</sup>

---

<sup>2</sup> Dow Jones Venture Source and the Center for Venture Research at the University of New Hampshire.

<sup>3</sup> See Alison Smale, "Germany Planning Quotas for Women in Boardrooms," *The New York Times*, November 26, 2014, [http://www.nytimes.com/2014/11/27/world/europe/germany-to-mandate-womens-membership-on-corporate-boards.html?\\_r=0](http://www.nytimes.com/2014/11/27/world/europe/germany-to-mandate-womens-membership-on-corporate-boards.html?_r=0). Accessed February 24, 2015. See also, European Commission, "Women on Boards: Commission Proposes 40% Objective," Press Release, November 14, 2012.

<sup>4</sup> Dow Jones, McKinsey & Company, *Fast Company*, Fortune 500 studies. See, for instance, Georges Desvaux, Sandrine Devillard-Hoellinger, and Pascal Baumgarten, *Women Matter: Gender Diversity, a Corporate Performance Driver*, McKinsey & Company, 2007.

As an angel investor, Golden Seeds seeks companies with barriers to entry, such as a deep patent portfolio. Women are underrepresented in patents, although their patents are more likely to be commercialized,<sup>5</sup> Ms. Wallace said.

Actively seeking woman-led technology companies, Golden Seeds considers the SBIR program to be a natural pipeline. But the firm often views government funding unfavorably, because investors, to whom Golden Seeds eventually sells its portfolio companies, believe the companies are in business only because they are government-certified as “disadvantaged” small businesses. Ms. Wallace also said that investors prefer DoD over NSF SBIR awardees because of the prospect for military procurement of the companies’ products.

Ms. Wallace noted that angel and venture capital investors exit their portfolio companies within 5 to 10 years, but science often requires 20 years to see success. Thus, early-stage SBIR funding is critical to support these companies through the R&D phase before the commercialization phase.

Ms. Wallace also shared suggestions from CEOs of Golden Seed’s SBIR portfolio companies. They recommended that the SBIR program communicate clearer selection criteria, including the requirement for letters of support. They also recommended that the SBIR program focus on funding R&D on diseases that the private market does not address, a recommendation reflecting Golden Seed’s life sciences portfolio.

## DISCUSSION

Grace Wang of the NSF addressed Ms. Wallace’s comments on investor skepticism of NSF grantees. She noted that 40 percent of NSF Phases I and II SBIR companies produced products. Acquisitions of such companies totaled \$2 billion over the past 8 years. Successes include Qualcomm, Symantec, and Intralase. Commercialization is best realized based on private-sector criteria, not on whether the NSF or DoD buy products, said Ms. Wang.

Christine Densmore of the National Institutes of Health SBIR program said that the government plays a critical role in early-stage seed funding to “de-risk” ideas and technology. In life sciences, Phase II funding is still not enough to attract private-sector investors to companies still awaiting patent issues. The government and investors need to better educate each other to close this gap, she said.

---

<sup>5</sup> National Women’s Business Council, *2012 Annual Report*, Washington, DC.

## 5

# Profiles of Scientists and Engineers and an Aging Workforce

Complementing the main focus of the day's proceedings, the second panel focused on overall profiles of the science and engineering (S&E) workforce and introduced a discussion of entrepreneurship and career paths among an aging workforce. The panel included presentations by Sally Rockey of the National Institutes of Health (NIH), Emilda Rivers of the National Science Foundation (NSF), and Jeff Makowka of the American Association of Retired Persons (AARP) and was moderated by Tyrone Taylor of Capital Advisors on Technology, who is a member of the committee studying the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs. While the panel did not focus on SBIR and STTR, it provided further context for the day's discussion. Dr. Rockey and Dr. Rivers described, respectively, the career paths of the biomedical workforce and of employed scientists and engineers, by age group, gender, and field. Of note, each described gender gaps, and Dr. Rockey added that only 2-3 percent of NIH grants' principal investigators are minorities. Finally, in the context of the discussion on an aging workforce, Mr. Makowka described the advantages and challenges faced by older entrepreneurs generally and AARP efforts to encourage entrepreneurship among those ages 50 years and over.

The content of the discussion and issues and recommendations raised by speakers is summarized below.



Sally Rockey  
National Institutes of Health

Leading off the second panel, Sally Rockey of the National Institutes of Health discussed findings from a study by the NIH of the biomedical workforce<sup>1</sup> that was designed to identify the sectors in which biomedical students end up working.

The number of biomedical PhDs has risen dramatically along with the doubling of the NIH budget from \$13 billion in 1998 to \$27 billion in 2003, reported Dr. Rockey. Over the past decade, the agency's annual budget has hovered around \$30 billion, and today the NIH primarily supports students through research grants. About 27 percent of NIH grants support female researchers, in contrast to the 55 percent of biomedical students and trainees who are women. Only 2 percent to 3 percent of NIH grants' principal investigators are minorities.

Summarizing the study's findings, Dr. Rockey explained: Biomedical students spend about six and half to seven years to get their PhDs by age 30 or 31, their first postdoc by age 35 or 36, and their first NIH grant by age 42, an age that generally involves significant family responsibilities. In comparison, chemistry students tend to earn their PhDs at age 29 and their postdocs at age 33. The lag in biomedicine milestones can make a difference in career path selection.

In addition, the biomedical workforce is getting older. In 1980, the average age of NIH principal investigators was 36 or 37. In 2010, the average age was 53 or 54, and 10 percent of NIH principal investigators were ages 65 and over. Yet, scientists tend to be most productive in their younger years. Most Nobel Prize winners, for example, come up with their winning ideas when in their 30s.

Lengthy biomedical training also depresses career earnings compared with other fields, she noted. Over the course of a lifetime, business students earn 33 percent to 50 percent more than scientists overall, because they start earning at a younger age, and ten years after graduation, biomedical researchers still make less than those who pursue other sciences, but their relative earnings even out after 30 years.

The most notable results of the study, she said, focus on the sectors in which U.S.-trained biomedical PhDs end up working: 18 percent in industry, 43 percent in academia, including nonresearch lecture and teaching positions, 6 percent in government, and 18 percent in research management. Expectations for the percentage in academia were higher.

An upsurge in foreign PhDs, aging of the biomedical workforce, and low salaries make academia a difficult destination, she argued. To address this challenge, the NIH launched the Broadening Experiences in Science Training program (BEST) to fund 25 organizations at \$250,000 a year to think about how

---

<sup>1</sup> Many of the statistics cited by Dr. Rockey in this section are from *Biomedical Research Workforce Working Group Report*, Bethesda, MD: National Institutes of Health, June 14, 2012.

to broaden training for scientists to enter industry, government, academia, and science-related fields. The hope is to apply best practices from these organizations, including collaboration between academia and the entrepreneurial private sector, more broadly.

*Emilda Rivers*  
*National Science Foundation*

Emilda Rivers of the National Science Foundation reported findings from the NSF's Scientists and Engineers Statistical Data System (SESTAT) 2003 and 2010 sample surveys, representing 21 million individuals under age 76 living in the United States with a bachelor's or more advanced degree in science and engineering (S&E) or a science and engineering-related (S&E-related) field or working in science and engineering.

Dr. Rivers noted that in 2003 the proportions of men and women among employed scientists and engineers were about even under age 30, but the relative proportion of employed men was higher in cohorts for age 30 and above. The largest gender gap occurred for ages 60 to 75, she said. In 2010, the gender gap narrowed for ages 30 and over, but the overall number of individuals employed at ages 60 to 65 is much higher.

The age trends were more pronounced among scientists and engineers working in S&E vs. non-S&E fields, Dr. Rivers noted. For engineers, little difference exists between age groups working in engineering. But most scientists working in science were ages 30 to 49, corresponding to NIH data described by the previous speaker. Of course, non-S&E occupations can include those in management in S&E-work.

In 2003, by sector, categorized as academia, government, and business/industry, including self-employed, incorporated and non-incorporated, a greater number of individuals worked in business/industry. Among PhD holders only, a larger number of individuals worked in academia. The 2010 data showed a similar pattern, except more of those ages 60 to 75 worked in business.

*Jeff Makowka*  
*American Association of Retired Persons*

Jeff Makowka of the American Association of Retired Persons explained that he manages AARP's Innovation@50+ initiative to spur innovation to meet the needs of those ages 50 and over. AARP also works on supporting those over age 59 who are creating new businesses. Mr. Makowka noted that every day 10,000 U.S. baby boomers turn age 65 and that at age 65 many are still energetic. According to a study by AARP and the Kauffman Foundation, those over age 65 create small businesses at twice the rate of those ages 54 to 55.

Mr. Makowka indicated that older entrepreneurs often possess several qualities that augur well for entrepreneurial success, including wisdom accumulated through the years, assets and savings, and potential funding through well-established networks. Yet, they also may face disadvantages compared to younger entrepreneurs. Many find it more difficult to acquire new skills, for example. Older entrepreneurs also have less time to recuperate from failure, sometimes lack the humility needed to learn from the inevitable mistakes they will make in a new business, and possess less flexibility either to hang onto an idea or to pivot, as the situation demands, he said. Of course, entrepreneurship also requires a personality that withstands challenges and setbacks, said Mr. Makowka.

To encourage 50+ entrepreneurship where it makes sense, Mr. Makowka said that AARP provides Web resources through a strategic partnership with the Small Business Administration. It also sponsors pilot workshops, including Spanish language programs, in three cities in partnership with the Kauffman Foundation. AARP makes available its Life Reimagined and Work Reimagined tools at local workshops. Its annual member meeting provides another opportunity for access to entrepreneurship workshops and tools.

Entrepreneurship among this population offers many benefits, said Mr. Makowka. The extension of workers' careers delays the drawdown in Social Security, while keeping older Americans more actively engaged with society.

## DISCUSSION

Dr. Wessner, then of the National Research Council, asked whether the NIH is considering changing rules to allow faculty to receive credit toward tenure for their SBIR work and whether the agency actively encourages SBIR applications as part of postdoc grants. He also asked whether the program evaluates faculty by whether their postdocs apply for SBIR awards.

Dr. Rockey said that faculty members are envisioned to participate in the new grant program, so they can train students. She said it was too early to know what proposals will come forward, but the program could conceivably consider SBIR activities as a measure of success. She said that the challenge is keeping biomedical PhDs interested in research. Moreover, the NIH understands the need to encourage undergraduate, not just graduate students, to pursue biomedical sciences.

Andrew Reynolds of the State Department asked whether government statistics include salaries, especially for those in business or Wall Street careers, to determine whether higher pay is an incentive to leave.

Dr. Rivers replied that NSF's data include salary distributions across all the categories studied and that NSF also collects that data in the Survey of Earned Doctorates of all PhDs in the United States. Survey respondents can write in their position description and title.

## 6

# SBIR/STTR and Support for Socially and Economically Disadvantaged Scientists and Engineers

The third panel introduced some agency perspectives on initiatives to broaden Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) program participation among underrepresented groups and included a presentation by a successful entrepreneur. The two lead speakers, Grace Wang of the National Science Foundation (NSF) and Karina Edmonds of the Department of Energy (DoE), focused on developing the pipeline of upcoming scientists and engineers. Dr. Wang emphasized the importance of enhancing the talent pool and retaining talent and described NSF's efforts, through the SBIR program, to encourage SBIR awardees to subcontract to Minority-Serving Institutions and community colleges and to hire high school and college students, postdocs, and K-12 and community college teachers. Ms. Edmonds argued for better outreach to graduate students, stronger support for application completion, and streamlining the award process—citing that she was unaware of the program while a PhD student at the California Institute of Technology. Eric Adolphe of CenterScope Technologies described the challenges he faced as a minority while pursuing an engineering degree and his perseverance in completing that degree, receiving an SBIR award, and building a successful company. Echoing the message of Ms. Edmonds, he cited the application process as a barrier to entry for all, and he expressed the need for mentors and role models, adding that successful SBIR awardees can offer assistance in completing applications. Jagannathan Sankar of North Carolina A&T State University (NCAT), the first Historically Black University to be selected by the NSF to be an Engineering Research Center (ERC), reviewed the university's efforts to cultivate entrepreneurship among its faculty and students. The panel was moderated by Tim McClees of the House

Committee on Armed Services, who argued that agency review panels should include more minorities and women from smaller institutions.

The content of the discussion and issues and recommendations raised by speakers is summarized below.

*Grace Wang*  
*National Science Foundation*

Grace Wang, director of the NSF's Industrial Innovation and Partnerships Division at the time of the workshop, opened the panel by highlighting her division's mission to drive U.S. innovation by investing in technology and its commercialization, an objective that cannot be accomplished without human talent. "The base of innovation capacity is people—that's the innovators and entrepreneurs," said Dr. Wang. That recognition drives the NSF's interest in broadening participation in science and engineering through the SBIR program. To channel more people into STEM careers, "first, we need to expand the talent pool, and second, retain the talent," said Ms. Wang. "We need to increase the pipeline and stop leakage of the pipeline," she said.

Dr. Wang shared a statistic based on Census Bureau data: In 2008, 65 percent of the total U.S. population belonged to groups that are underrepresented in science and engineering, that is, women, African Americans, Hispanics, Native Americans, and people with disabilities. Yet, only 33 percent of people from these groups were employed in science and engineering occupations in 2006, according to NSF data.

To broaden participation, Dr. Wang noted that the NSF runs several initiatives to encourage SBIR Phase II awardees to hire high school and college students, postdocs, and K-12 and community college teachers including:

- Research Assistantships for High School Students, where Phase II awardees hire high school students for up to \$6,000 per student.
- Research Experience for Teachers, where Phase II awardees hire K-12 teachers for up to \$10,000 per teacher to return the culture of innovation and entrepreneurship to the classroom.
- Community College Research Teams, where Phase II awardees receive up to \$40,000 and subcontract at least 75 percent of this award to a community college, working with at least one faculty member and one student as a team.
- Research Experience for Undergraduates, the most popular program among Phase II awardees, where companies hire college interns for up to \$8,000 per student. About 40 percent of Phase II awardees have hired at least one such student.

- The Phase IIA program, which gives Phase II awardees \$100,000 with the requirement to subcontract 70 percent of the award to Minority-Serving Institutions to conduct research together.
- The Small Business Post-Doc Research Diversity Fellowship, which enables postdocs to work for Phase II companies for up to \$75,000 each.
- The Veteran's Research Supplement, which enables Phase II companies to hire veteran high school and college students, teachers, and community college faculty for up to \$10,000 per veteran.

In addition, the NSF attempts to support existing principal investigators by providing them with specific networking and mentoring opportunities at the annual awardees' conference.

*Karina Edmonds*  
*Department of Energy*

Karina Edmonds of the Department of Energy explained that her job is to encourage small companies and entrepreneurs to commercialize innovation from the national laboratories. Other federal agencies, such as the National Institute of Standards and Technology, National Institutes of Health, and Department of Defense, have adopted similar programs, and the Environmental Protection Agency is considering launching one.

Noting that she does not speak for the agency, she expressed disappointment in the DoE's record of funding the underrepresented. Nevertheless, the DoE's Energy Efficiency and Renewable Energy Office plans to double its female applicants. The DoE's Office of Economic Impact and Diversity funds the hiring of graduate students from Historically Black Colleges and Universities to work at the national labs and supports the commercialization of the technologies developed by the students. In addition, Dr. Edmonds introduced a program two years prior to the workshop called America's Next Top Energy Innovator to enable startups to license up to three patents from DoE for an upfront fee of \$1,000 to commercialize the technology.

Dr. Edmonds said that a relatively small percentage of woman and minority science and engineering PhDs apply for SBIR grants, perhaps because many don't know about the program. As a PhD student at the California Institute of Technology, she herself was unaware of SBIR grants. She recommended that the SBIR program work harder to make graduate students aware of the program.

Dr. Edmonds also suggested that the SBIR program provide more information to prospective applicants to help them complete their applications. The U.S. government has taken many steps to simplify processes, and "the SBIR is an area ripe for innovation in terms of how to make it easier for folks to apply," she said.

Dr. Edmonds also commented that streamlining the SBIR award process would benefit women and minorities who cannot afford to finance themselves during the long wait between grant applications and the award selection.

*Eric Adolphe*  
*CenterScope Technologies*

Eric Adolphe of CenterScope Technologies offered the perspective of someone who has won 17 SBIR awards, successfully commercializing six. He shared his life story to illustrate the challenges that individuals from underrepresented groups face in pursuit of STEM careers. At SUNY-Buffalo, Mr. Adolphe originally majored in arts on a full scholarship. He abruptly changed his major to engineering on a bet with a roommate, who said that none of the college's minority students could understand the challenges of engineering because they all majored in liberal arts. The college pulled Mr. Adolphe's scholarship, and he enrolled in the less expensive City University of New York. Still unable to afford his living expenses, he became homeless for half a year.

A friend told him about the National Action Council for Minorities in Engineering scholarship, and he won. After graduating, he worked for a federal defense contractor that promised him 20 percent royalties on sales of any product he originated. Mr. Adolphe built and sold a product to the Federal Aviation Administration, producing \$300 million in sales. When the company failed to give him his share of royalties, he quit to start his own company.

At a trade show, Mr. Adolphe met Jim Garrett, an African American, who agreed to incubate the company. There, Mr. Adolphe learned about the SBIR program from a pamphlet passed around the office asking for applicants to solve an issue with NASA's Challenger. On his first try, Mr. Adolphe won the SBIR award.

To develop the technology, the others in the company met without inviting Mr. Adolphe. He then established his own diverse team, comprised, as he put it, of "[his] cousin, a disabled Pakistani scientist, a heavy metal fan, and a former college track star" to take charge of the project. During the team's presentation to NASA, the agency's representatives said they would guarantee Phase II funding if the team could solve a particularly difficult problem. Mr. Adolphe said that the team wrote code overnight and received the funding, winning the NASA SBIR of the Year Award. Since then, Mr. Adolphe was inducted into the National Inventors Hall of Fame and won the SBIR program's Tibbetts Award. In 2006, he sold his company and began teaching at American University and consulting for startups on how to apply for SBIR awards. He recommended that applicants seek help in writing their proposals from successful awardees.

Mr. Adolphe argued that money is one of the largest barriers to STEM careers for underrepresented populations. Many minorities opt to not pursue PhDs because of short-term financial concerns about career survival. In addition, he noted that not enough students enter the pipeline because they lack mentors

and role models. “Every time I was about to quit, someone pulled me out,” Mr. Adolphe said.

*Jagannathan Sankar*  
*North Carolina A&T State University*

In an additional panel presentation, Jagannathan Sankar, Distinguished University Professor of mechanical engineering at North Carolina A&T State University, discussed his work leading the university’s NSF Engineering Research Center. The first Historically Black University to win the coveted grant, which supports university research in partnership with industry, Dr. Sankar indicated that NCAT is a leader in broad-based advanced materials creation. Its ERC aims to create world-leading innovative technologies in biodegradable metals for medical implants that dissolve inside the body when no longer needed. The revolutionary innovation would eliminate the need for multiple surgeries and would reduce health care costs.

Following an interdisciplinary strategy, shared Dr. Sankar, the ERC for Revolutionizing Metallic Biomaterials (RMB) trains next-generation students and researchers to become global leaders in the creation of new industries and spinoffs. This is achieved by working with current leaders, ranging from the University of Pittsburgh to the University of Cincinnati (USA partners), to the Hannover Medical School in Germany (a global partner), as well as appropriate large companies and SBIR firms. Undergraduate, graduate, and faculty researchers also participate in research exchange and travel programs to Germany and Asia.

In addition to 10 foundational science innovation projects, the ERC is pursuing eight mission-oriented projects, following a specific plan identifying clinical needs, industry partners, patent positions, and other factors. It also works with world leaders establishing industry standards.

For example, in the process of fulfilling its mission, ERC’s work supports innovations and spinoffs, such as NanoMag and OrthoKinetic Technologies, two small businesses working in SBIR projects on *in vivo* testing of lightweight magnesium, which disappears in the body over time, and GLP mechanical evaluation activities. Further, ERC-RMB has recently signed a licensing agreement with a California-based research group, Incube Labs, for commercializing the innovation.

## DISCUSSION

An audience member noted NASA’s unheralded success in investing in computer communications hardware at Minority-Serving Institutions, such as Morgan State University. These connections grew into close daily working relationships until the program ended due to budget constraints.



Dr. Wang said NSF has visited the MIT, Stanford, and Carnegie Mellon business schools, but melding the technology and business disciplines does not address all that is needed to provide S&E researchers with business and entrepreneurship skills. Scientists and engineers also need enough self-knowledge to step aside for another CEO, if needed.

Mr. Adolphe said that partnering a minority institution with a business school is not enough. Rather, the SBIR applicant needs to partner with someone who is skilled at SBIR applications to win an award.

Dr. Edmonds noted that the National Advisory Council on Innovation and Entrepreneurship encourages business competitions at colleges and universities. DoE sponsored a national business competition last year at six regional nodes.

An audience member said that if federal agencies do not address the drop in Phase I and II woman- and minority-owned SBIR awardees, then Congress should consider mandating outcomes with the next reauthorization.

Timothy McClees said that Congress is looking at these issues. In addition, he said, agency reviewers need to come from the schools from which woman and minority applicants are drawn. Today, many SBIR reviewers come from large institutions and are drawn to researchers from organizations they know and trust. Woman and minority reviewers from smaller institutions could level the playing field over time.

Dr. Wang said that an NSF study found that woman and minority SBIR awardees do not have lower funding rates than non-woman- or minority-owned businesses but that women and minorities do get a low numbers of awards. Thus, the NSF is working on increasing the number of applications in the pipeline.

## 7

# Cases of Successful High-Tech Entrepreneurship

The fourth panel included lessons from two successful female entrepreneurs working in the defense space and a description of a program to provide entrepreneurship training to women. ML Mackey of Beacon Interactive Systems and Alison Brown of NAVSYS described the challenges they have faced as female entrepreneurs, and both described the Small Business Innovation Research (SBIR) program as critical to the development of their companies. Ms. Mackey argued for anonymous review of SBIR applications' technical merit and for greater diversity on evaluation panels. Dr. Brown noted the importance of partnering with larger companies in the defense space and urged greater incentives for prime contractors to outsource to small companies and to protect small companies' intellectual property. Jane Muir described how the program she founded, Empowering Women in Technology Startups (ewits®), helps women overcome barriers to entering the tech startup world.

In her role as panel moderator, Kevin Wheeler of the Senate Committee on Small Business and Entrepreneurship underscored the importance of diversity to that Senate Committee, which worked to provide agencies 3 percent of SBIR budgets for program management and authorized the National Academies' studies of the SBIR program every 4 years to measure results. She suggested that these funds could be used to improve outreach and reduce barriers to completing applications.

The content of the discussion and issues and recommendations raised by speakers is summarized below.

*ML Mackey*  
*Beacon Interactive Systems*

The first panel speaker, ML Mackey, CEO of Boston-based Beacon Interactive Systems, an SBIR company, told her personal story to illustrate the challenges of women in STEM careers. Having grown up poor, she pursued engineering largely for financial reasons. “I was poor and did not want to live that way as an adult,” she said. My choice to get an engineering degree was based on wanting to make money, and the highest available scholarship was for electrical engineering.” To encourage young women to enter the field, she recommended more female role models and showcasing to prospective students the creative, problem-solving aspects of science and engineering to counter the often dry academic curricula.

After Ms. Mackey met her husband, then getting a Harvard MBA, they started a company in 1994. The company developed software for commercial clients, including MetLife, Olympus, and IBM. After the e-business crash in 2001, the company survived by successfully gaining a Navy SBIR award, whose solicitation they happened to see. “We would not have found the program if we were not in dire straits,” she said. “Nothing reached out to me as a small business owner to participate in SBIR.” The company now provides products and services to the Navy.

As the only woman in meetings with Navy clients, Ms. Mackey said she often felt excluded from the male-dominated banter until her husband gave her a book of insults and comebacks. At a meeting, Ms. Mackey threw down the book in a mock challenge to her male colleagues. Afterwards, she succeeded in breaking the ice and found greater acceptance among them. “All we had to do was to acknowledge I was different and incorporate the difference,” she said. People “tend to see the ‘not like us’ before they see the technical merit,” she said.

Ms. Mackey recommended that the SBIR program be maintained as a competitive award program with clear evaluation criteria based on technical merit. Review of an application’s technical merit section should be conducted anonymously to remove bias, and evaluation panels should be more diverse, she said. If not immediately, then over time, diverse evaluation panels should lead to more diverse awardees, she argued.

*Alison Brown*  
*NAVSYS*

The next speaker, Alison Brown, CEO of NAVSYS, said the SBIR program was pivotal to incubating her company, which she co-founded in 1986 after leaving a job in California to join her husband in a move to Colorado for his job teaching at the Air Force Academy. After receiving her PhD, Dr. Brown worked on global positioning systems (GPS), then a new satellite technology. The company’s first SBIR award in 1988 enabled it to build the GPS Translator. NAVSYS

won subsequent SBIR awards by acknowledging the need to partner with larger companies to commercialize innovations in transition to Phase III. Such partnerships are a necessity for startups, she said, because only large companies can bid for defense contracts.

Dr. Brown said that NAVSYS technology has provided new capabilities and lower costs for the Department of Defense (DoD). The NAVSYS Jamming Detection and Location Phase III SBIR project, for example, helps solve the problem of GPS jamming by the enemy. The DoD program officer wanted new anti-jamming technology, and NAVSYS offered a cheaper, more effective crowdsourcing solution than the DoD had originally contemplated, said Dr. Brown. The NAVSYS system receives information from GPS receivers in the field and sensors already carried by soldiers to identify jamming incidents. By downloading client software on their computers, any government agency can access this information royalty-free via a government computer network. Dr. Brown described that the system acquired hundreds of users within 2 years and is now a program of record because of the high number of users.

To solve another urgent military need, said Dr. Brown, NAVSYS provided the Air Force with a solution called the Talon NAMATH. To contain collateral damage, the Air Force needed technology to aim small bombs developed for the Iraq War. Using knowledge from technology that it developed for the Federal Aviation Administration, NAVSYS created a GPS precision solution that did not require expensive equipment on the ground. Likewise, NAVSYS's precision targeting technology, developed mostly with SBIR funds, transitioned into FLIR Systems' Star SAFIRE® product providing the U.S. military with stable, GPS-enabled, high-accuracy pointing for surveillance using high-precision electronic sensors.

Dr. Brown highlighted a major challenge for defense technology startups: the SBIR program supports the development of technology to the DoD's Technology Readiness Level (TRL) 6, but DoD is not interested in funding companies until they reach TRL8. Specifically, Dr. Brown identified the following issues:

- DoD prefers to deal with its own prime contractors and does not fund SBIR awardees to a stage where they can enter DoD programs.
- Prime contractors lack incentives to outsource to would-be competitors, such as SBIR awardees.
- DoD recognizes neither the return on investment it gets from small business innovation nor the missed opportunity when small businesses cannot transition to Phase III.
- Lack of enforcement of SBIR policies rewards "bad practices" discouraging SBIR involvement.

Dr. Brown suggested legislative incentives to encourage large companies to outsource to small companies and to protect small companies' intellectual

property. “If you just encourage small businesses to get Phase I and II [awards], the program is broken,” she said. “That’s not what the SBIR is about; there’s no commercialization.” If the government cannot commercialize the product, then agencies miss an opportunity to reap a return on investment, she said.

*Jane Muir*  
*University of Florida and AUTM*

Jane Muir, director of the University of Florida’s Florida Innovation Hub, a 50,000-foot incubator with 25 startups, offered her perspective as part of the panel. Ms. Muir said that she started the Empowering Women in Technology Startups (ewits®) program in 2011 to overcome what she termed as “the distressing lack of women among the leadership of startup companies in the incubator.” The dismal statistics, she said, reflected a larger national and global need for more women in tech startups. By providing women with entrepreneurial training in a nurturing environment, ewits® helps participants overcome barriers to entering the tech startup world, including the lack of role models, self-confidence, support systems, mentors, and work-life balance, and their own tendency to wait for an invitation.

The University of Florida is one of the nation’s largest 15 research universities, she said, funding \$700 million in research in 2013. Typically for every \$2 million to \$2.5 million in research, a new discovery is disclosed to its Office of Technology Licensing. That office assesses the technology’s patentability and commercial potential and typically licenses one-third of those discoveries to major corporations, one-third to small businesses, and one-third to startups. Last year, she said, the University of Florida started 17 companies based on university research discoveries.

In Florida, 99.7 percent of companies have fewer than 100 employees, according to Ms. Muir. These companies provide 82.4 percent of the jobs in the state, and less than 63 percent have fewer than 10 people.<sup>1</sup> Startups play a key role in job creation in the state, she said, yet while technology is an abundant resource in Florida, experienced entrepreneurs are among the least available resources.

The ewits® program introduces women to the possibilities of entrepreneurship and nurtures budding female entrepreneurs, Ms. Muir said. Women still represent less than 15 percent of Fortune 500 CEOs. Gender bias is ingrained, and even women are biased against women, said Ms. Muir. According to a recent Yale University study<sup>2</sup> she cited, science professors (both men and women) at U.S. universities were less inclined to hire female undergraduates than their male counterparts and when hiring were inclined to pay women a lower salary.

---

<sup>1</sup> *Florida Trend*, January 2011.

<sup>2</sup> Corinne A. Moss-Racusin, John F. Dovidio, Victoria L. Brescoll, Mark J. Graham, and Jo Handelsman, “Science faculty’s subtle gender biases favor male students,” *Proceedings of the National Academy of Sciences*, 109(41): 16474-16479, October 9, 2012.

More encouraging, said Ms. Muir, are statistics showing that women are getting academic degrees at a rate faster than men. Women represent two-thirds of U.S. purchasing power. Employees prefer to work for women, and woman-led startups generate significantly higher returns for venture capitalists, she said. Moreover, woman-led startups have much higher rates of initial public offerings.

Yet female participation in tech startups remains low. ewits<sup>®</sup> envisions a world in which gender is no longer an issue, Ms. Muir said. The first session of ewits<sup>®</sup> in 2012 identified nine patented technologies from the University of Florida and accepted 57 women for more than 9 weeks of training. Paired with an experienced female mentor, each participant worked within a virtual, cross-disciplinary management team to prepare a business plan and investor presentation. ewits<sup>®</sup> is still compiling the outcomes of the program. Already, plans for two startups are under negotiation.

The program has been offered several times since the pilot, and thus far 150 women have participated. Evaluations consistently use the words “life changing.” Ms. Muir is gearing up to provide for the fourth cohort of women in ewits<sup>®</sup> in early 2015<sup>3</sup> and is currently working to identify pilot locations interested in offering the ewits<sup>®</sup> program. With a goal of one location in all 50 states, her hope is to see 2,500 women in the United States benefit from this program.

## DISCUSSION

Ms. Wheeler suggested that each agency institute three changes for 4 years. For example, an agency could conduct outreach at the same conferences to see whether interest grows. “There’s effectiveness in repetition,” she said. Getting more applications is also important, she said, because awards are proportional to applications, according to the U.S. Government Accountability Office. Reducing application costs and providing funds for applicants to work with proposal-writing experts are possible steps.

An audience members suggested that data be collected from first-time applicants to understand how they learned about the SBIR program, whether through a solicitation or other avenue.

---

<sup>3</sup> December 2014 update.



## 8

## Roundtable Discussion

Michael Borrus, of X/Seed Capital Management, who is a member of the committee studying the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, moderated a roundtable discussion of key issues and proposed steps. At the roundtable's close, prior to the final remarks by Dr. Gansler, Mr. Borrus reflected on the day's proceedings, noting the variety of suggestions and examples heard throughout the day and suggesting that it is unclear what mix of these can be effective in addressing the problem of increasing participation among minorities and women. He argued that these must be tested while being mindful of whether they can be scaled. Overall, he noted that "The only thing that works is comprehensive attention to the problem itself at all points and a commitment to do that," adding that we must "remove roadblocks, align incentives, measure the results; rinse and repeat; and do it 'til you get it right." This viewpoint complemented remarks by agency representatives who participated in the brief roundtable discussion. The content of the discussion and issues and recommendations raised by speakers is summarized below.

Matthew Portnoy, SBIR/STTR program coordinator at the National Institutes of Health (NIH), said that the NIH has a diversity of supplement programs to support underrepresented groups on SBIR and STTR awards. The NIH is taking steps to improve diversity among SBIR awardees. The NIH is targeting outreach to woman-owned and socially and economically disadvantaged businesses. The NIH is also coordinating its SBIR/STTR programs with the NIH Institutional Development Award (IDeA) program to target underrepresented states. The NIH's annual IDeA Symposium includes sessions on the SBIR/STTR programs, and the NIH Annual SBIR/STTR Program includes a session on the IDeA program.



Christopher Rinaldi, the current chief commercialization officer and former SBIR program administrator at the Department of Defense (DoD),<sup>1</sup> said that woman-owned small businesses comprise about 10 percent to 14 percent of DoD awardees, depending on the year. Federal agencies should continue to formulate operational plans to harness the potential of America's growing minority populations, weighing pros and cons of various measures.

Mr. Rinaldi went on to say that the National Science Foundation's (NSF) mission and programs to increase the numbers of people from underrepresented groups in the science and engineering pipeline provides a model for all federal agencies. The DoD currently awards scholarships, and the NSF program giving Phase II awardees with funds to hire students and faculty from underrepresented groups offers another idea for how to expand the pipeline. "This program is a lot less about the technology than about the people," said Mr. Rinaldi. "People just need to know how to apply; they need encouragement and mentors. It's all about people, connections, and linking it all up."

Joseph Hennessey, senior advisor for Small Business Innovation Research at the NSF, noted that NSF's funding is in the form of grants, giving the agency more flexibility than contracting agencies to provide supplemental programs for Phase II SBIR companies to hire female and minority students, faculty, and others.

Dr. Hennessey noted that the NSF launched the I-Corps<sup>TM</sup> program to help universities translate their research findings into innovations, linking basic researchers to mentors. The program is beginning to receive SBIR applications from graduates of that program. The NSF could consider integrating elements of the ewits<sup>®</sup> program into this program through webinars. The NSF uses webinars after each solicitation to explain to potential applicants what the agency wants and how to submit a competitive application. Dr. Hennessey said that webinars probably increased the number of quality applications received by 25 to 30 percent, although it is unclear how many of those came from members of underrepresented groups.

Still, he said, the dearth of underrepresented groups in innovation is reflected in the number of applications received by the NSF, not in the success rates. "The challenge for us now is to get them to get engaged in the innovation process and become entrepreneurs."

Dr. Hennessey indicated that the NSF's nine program topic areas are managed by program directors with extensive technical and business experience who provide significant individual mentorship to NSF grantees. He said that the NSF also endeavors to have as much diversity as possible on its review panels to serve also as ambassadors to the community.

---

<sup>1</sup>Christopher Rinaldi held the position of DoD SBIR program administrator at the time of the workshop.

Richard Leshner, NASA's SBIR/STTR coordinator at the time of workshop, said that NASA's SBIR program has focused on Phase I and Phase II contracts and could learn from other agencies about increasing its focus on commercialization. With the retirement of the space shuttle, NASA is in transition and has adopted eight new programs for space technology development at all Technology Readiness Levels. Those programs have explicit objectives to reach undergraduate and graduate students. To accomplish those objectives, Dr. Leshner said, NASA could work more closely with its Office of Small Business Programs, which runs 10 small business centers around the country. "No single right idea or solution is likely to increase diversity of SBIR contracts and grants," he said.

Ronald Cooper of the U.S. Small Business Association (SBA) said that in order to solve the SBIR program's diversity shortfall, federal agencies need to improve outreach and the application process and consider whether to adopt new incentives. The SBA performs a coordinating role for outreach and could maintain a central database of potential outreach partners, including nonprofits and state and local development institutions. Mr. Cooper said that the National Academies' survey studies would be helpful to such efforts. Assessing woman and minority SBIR participation rates within the relevant economic and demographic context will give agencies a better sense of how to focus their outreach efforts.

Closing the workshop, Dr. Gansler thanked the speakers and attendees and emphasized the importance of maintaining the SBIR program as a merit-based program, based on incentives rather than mandated outcomes.



# APPENDIXES



# Appendix A

## Agenda

### **Innovation, Diversity, and Success in the SBIR/STTR Programs**

**February 7, 2013**

**Lecture Room  
National Academy of Sciences  
2100 C Street NW  
Washington, DC**

- 9:00 AM **Welcome**  
*Charles Wessner, The National Academies*
- 9:15 AM **Introduction**  
*Jacques Gansler, University of Maryland*
- 9:30 AM **Keynote Address: Encouraging Innovation and Entrepreneurship**  
*Winslow Sargeant, Office of Advocacy, Small Business Administration*
- 10:00 AM **Overview of Demographic Data from NRC SBIR Evaluations**  
*Peter Grunwald, Grunwald Associates*
- 10:45 AM **Panel I: Women and the SBIR Program**  
*Moderator: Christina Gabriel, University Energy Partnership*
- Improving Participation in SBIR**  
*Tanaga Boozer, U.S. Patent and Trademark Office*
- Empowering Women Entrepreneurs and Investors**  
*Peggy Wallace, Golden Seeds*
- 11:30 AM **Panel II: Entrepreneurial Boomers and Emerging Millennials:  
New Options for SBIR and STTR**  
*Moderator: Tyrone Taylor, Capitol Advisors on Technology*

**Careers for Younger Scientists and Engineers: Parallels with other NIH Programs**

*Sally Rockey, National Institutes of Health*

**Changing Age Profiles of Scientists and Engineers**

*Emilda Rivers, National Science Foundation*

**Older Scientists and Engineers: A “New” Source of Expertise for SBIR Programs?**

*Jeff Makowka, AARP*

1:45 PM

**Panel III: SBIR/STTR and Support for Socially and Economically Disadvantaged Scientists and Engineers**

*Moderator: Tim McClees, House Committee on Armed Services*

**NSF SBIR/STTR Program: Broadening Participation Initiatives**

*Grace Wang, National Science Foundation*

**Improving Outreach at the Department of Energy**

*Karina Edmonds, Department of Energy*

**Reaching out to Disadvantaged Scientists and Engineers: Views of a Multiple SBIR Winner**

*Eric Adolphe, CenterScope Technologies*

**Lessons from the North Carolina A&T Engineering Research Center**

*Jagannathan Sankar, North Carolina A&T*

3:15 PM

**Panel IV: Cases of Successful High-Tech Entrepreneurship**

*Moderator: Kevin Wheeler, Senate Committee on Small Business and Entrepreneurship*

**The Beacon Interactive Story**

*ML Mackey, Beacon Interactive Systems*

**The NAVSYS Story**

*Alison Brown, NAVSYS*

**Empowering Women in Technology Startups**

*Jane Muir, University of Florida and AUTM*

4:15 PM     **Closing Roundtable: Key Issues and Next Steps Forward**  
*Moderator: Michael Borrus, X/Seed Capital Mangement*

*Matthew Portnoy, National Institutes of Health*

*Christopher Rinaldi, Department of Defense*

*Joe Hennessey, National Science Foundation*

*Richard Leshner, NASA*

*Ron Cooper, Small Business Administration*

4:50 PM     **Closing Remarks**  
*Jacques Gansler, University of Maryland*

5:00 PM     **Adjourn**





# Appendix B

## Participants List

### Innovation, Diversity, and Success in the SBIR/STTR Programs

February 7, 2013

Lecture Room  
National Academy of Sciences  
2100 C Street NW  
Washington, DC

Eric Adolphe  
CenterScope Technologies

Giorgio Billi  
ENSEL

Lauren Anderson  
White House Office of Science and  
Technology Policy

Tanaga Boozer  
U.S. Patent and Trademark Office

David Audretsch  
Indiana University

Michael Borrus  
X/Seed Capital Management

Robert-Allen Baker  
Vital Strategies

Todd Brethauer

Robert Brooke  
Center for Innovative Technology

Frank Barros  
Department of Homeland Security

Alison Brown  
NAVSYS

Lezli Baskerville  
National Association for Equal  
Opportunity in Higher Education

Edsel Brown  
Small Business Administration

Ngozi Bell  
SBA Office of Advocacy

Robert Brunson  
U.S.-Israel Science and Technology  
Foundation

Giulio Busulini  
Embassy of Italy

Bristol English  
House Committee on Science, Space  
and Technology

Erin Cadwalader  
Association for Women in Science

Cynthia Firman  
National Aeronautics and Space  
Administration

Gail Cassell  
Harvard Medical School

Christina Gabriel  
University Energy Partnership

Roy Chrobocinski  
ASME

Jacques Gansler  
University of Maryland

Carmen Cioc  
Department of Energy

Robin Gaster  
Innovation Competitions LLC

McAlister Clabaugh  
The Academies

Jere Glover  
Brand Law Group

Mary Clague  
Department of Commerce

Frank Graeff  
Ridge Policy Group

Ronald Cooper  
Small Business Administration

Peter Grunwald  
Grunwald Associates

Lindsay D'Ambrosio  
National Science Foundation

Kevin Gutierrez  
Department of Homeland Security

David Dawson  
The Academies

Lamont Hames  
UNCF

David Dierksheide  
The Academies

Joe Hartz  
House Committee on Small Business

Karina Edmonds  
Department of Energy

Tom Held  
MetaMedia Training International, Inc.

Tim Edwards  
STEMconnector®

Joe Hennessey  
National Science Foundation

Kimberly Elcess  
Brookhaven National Laboratory

Robert Hershey  
Robert L. Hershey, P.E.

Heidi Jacobus Cybernet Systems	Joseph Misanin Office of the Secretary of Defense
Peter Kmec Embassy of the Slovak Republic	Jane Muir University of Florida; AUTM
Charles Kolb Aerodyne Research, Inc.	Gracie Narcho National Science Foundation
Richard Leshner National Aeronautics and Space Administration	Diane Palmintera Innovation Associates
Ann Liebschutz U.S.-Israel Science and Technology Foundation	Clark Peterson
Karin Louzada Royal Netherlands Embassy	Alicia Pettibone U.S. Department of Homeland Security
Tizoc Loza Northrop Grumman Corporation	Rachel Pohl Georgetown University
Donna Lynn MetaMedia Training International, Inc.	Matthew Portnoy National Institutes of Health
Neil MacDonald Federal Technology Watch	Jared Rader DIAMONDEFENSE
ML Mackey Beacon Interactive Systems	Andrew Reynolds Department of State
Jeff Makowka AARP	April Richards U.S. Environmental Protection Agency
Kurt Marek National Institutes of Health	Christopher Rinaldi Department of Defense
Tim McClees House Committee on Armed Services	Emilda Rivers National Science Foundation
Mary McManmon U.S. Department of Energy	Sally Rockey National Institutes of Health
	Becky Roof National Institutes of Health

Theodore Roumel TRGLLC	Poornima Upadhya Brookhaven National Laboratory
Mary Ann Rozum U.S. Department of Agriculture	Christine Villa BRTRC
Charles Russomanno Department of Energy	Peggy Wallace Golden Seeds
Jagannathan Sankar North Carolina A&T	Grace Wang National Science Foundation
Amalia Santiago U.S. Department of Energy	Ahson Wardak Small Business Administration
Winslow Sargeant Small Business Administration	Charles Wessner The Academies
Ilga Semeiks U.S. Government Accountability Office	Kevin Wheeler Senate Committee on Small Business and Entrepreneurship
Jennifer Shieh National Cancer Institute	Gerald Whittaker Morgan State University
Sujai Shivakumar The Academies	John Williams Department of Defense
Chemain Slater Indiana University	Patrick Windham Windham Consulting
Jeffrey Sohl University of New Hampshire	Chad Womack UNCF
Tyrone Taylor Capitol Advisors on Technology	Kelly Wright NOAA
Xueke Tian S&T Daily	Catherine Yang The National Academies
Irma Turcios-Payne Department of Homeland Security	Lisa Younger Small Business Administration

## Appendix C

# Data on Woman and Minority Participation in the SBIR Program at the Department of Defense

As part of its review of the SBIR program at the Department of Defense, the the National Academies of Sciences, Engineering, and Medicine committee on Capitalizing on Science, Technology, and Innovation collected data on woman and minority participation. These data are presented in the committee's report, *SBIR at the Department of Defense*,<sup>1</sup> and the report's presentation of the data is reproduced in this appendix. The following excerpts from Chapter 2 of that report focus on Phase I awards and Phase II awards respectively.

### Phase I SBIR Award Demographics<sup>2</sup>

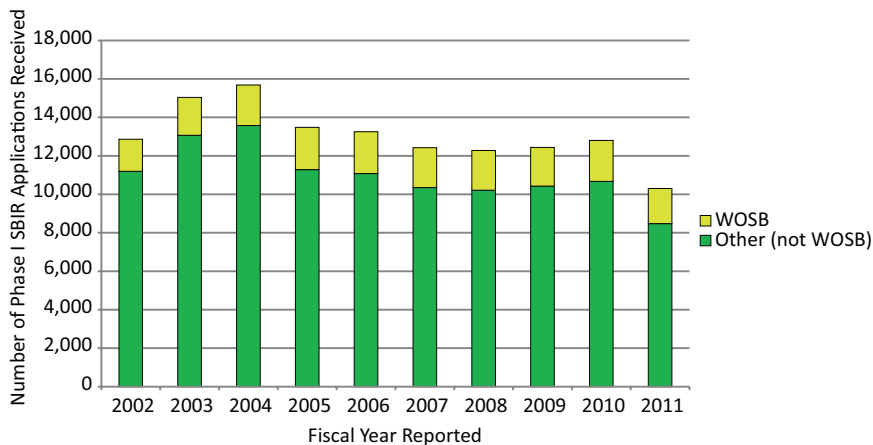
#### Woman-owned Small Businesses (WOSB)

Congress mandated that the participation of women in the SBIR program be fostered and encouraged (Chapter 3 discusses additional evidence about female participation in the context of outcomes). The number of applications received from WOSBs remained largely flat over the study period (see Figure 2-8), even though the number of applications received from all companies declined. Overall, the number of awards to WOSBs remained constant, although with year-to-year variation, while the percentage of awards to WOSBs increased, especially after FY2008 (see Figure 2-9). Although overall numbers were relatively flat, there was

---

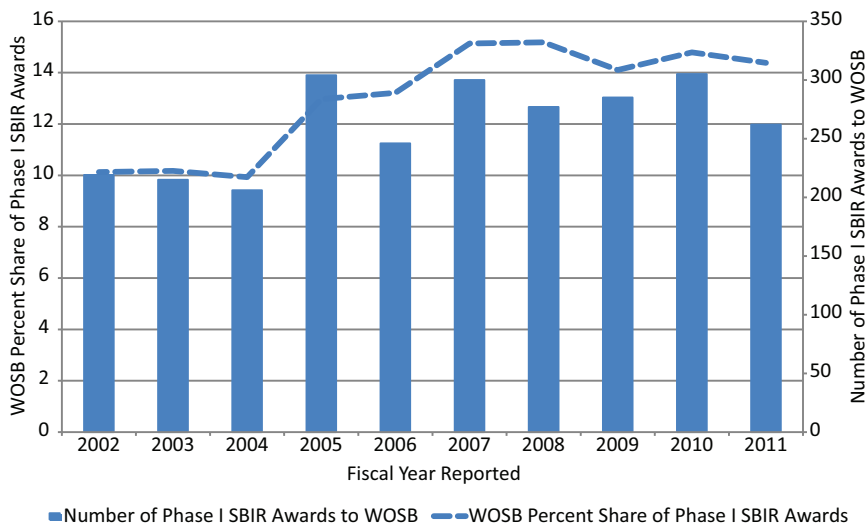
<sup>1</sup> National Research Council, *SBIR at the Department of Defense*, Washington, DC: The National Academies, 2014.

<sup>2</sup> The following text relating to Phase I awards appears on pp. 33-41 of National Research Council, *SBIR at the Department of Defense*, Washington, DC: The National Academies Press, 2014. Tables 2-2 and 2-3 have been removed from this excerpt because they do not relate to the quoted text.



**FIGURE 2-8** Phase I SBIR applications from woman-owned small businesses (WOSB), FY2002-2011.

SOURCE: DoD awards and applications database.

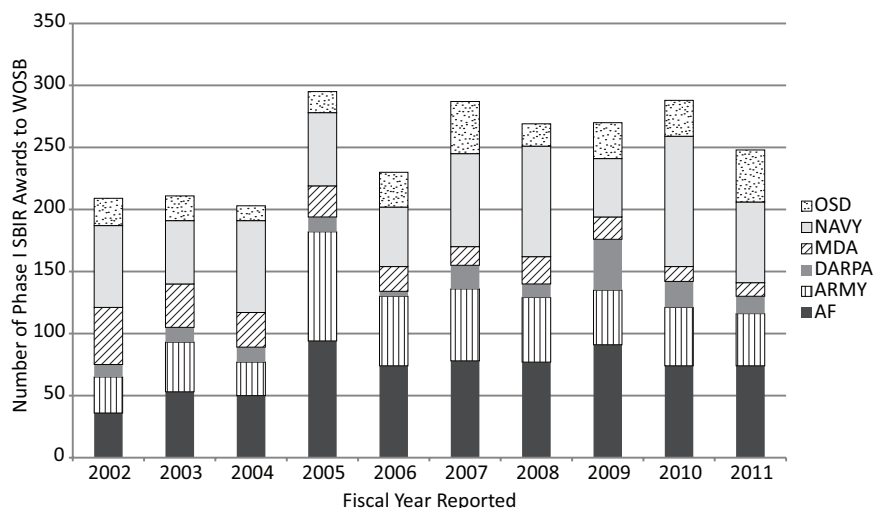


**FIGURE 2-9** Phase I SBIR awards and award share for woman-owned small businesses (WOSB), FY2002-2011.

SOURCE: Data from DoD awards and applications database.

considerable variation in the awards to WOSBs made by individual components (see Figure 2-10).

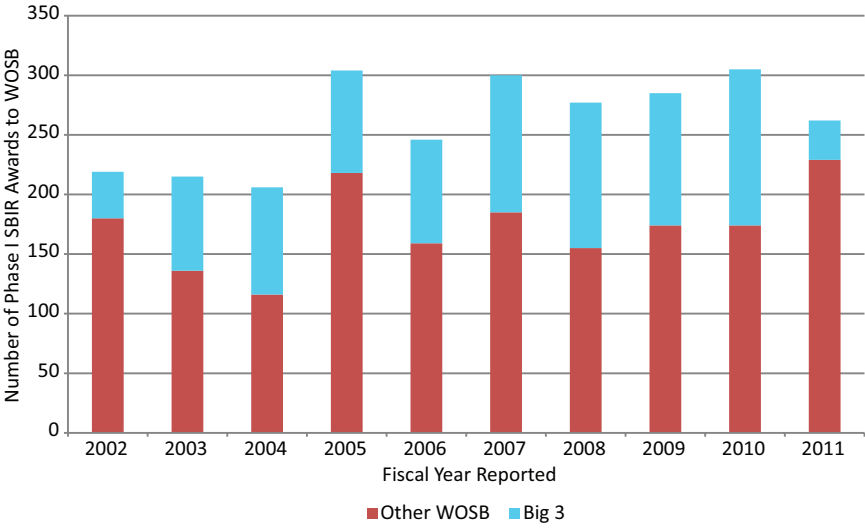
In reading this data, it is important to keep in mind the very large role played by three WOSBs: Physical Optics, Intelligent Automation, and CFD Research. All were wholly or in part founded by their female owners, who continue to play a major role at each, so they clearly meet the Small Business Administration (SBA) standard for WOSBs. Combined, they accounted for about 34 percent of all Phase I awards to WOSBs during the study period; in some years, they accounted for much more than 40 percent, as illustrated in Figure 2-11 (numbers dropped sharply in FY2011 for reasons not yet understood). The figure also shows that the number of Phase I awards made to the remaining companies remained largely flat (until FY2011, for which only partial data are likely yet available). More generally, the top 20 WOSB awardees accounted for about 5.4 percent of all Phase I awards and about 42 percent of awards to WOSBs (see Table 2-4).



**FIGURE 2-10** Phase I SBIR awards to woman-owned small businesses (WOSB) by component, FY2002-2011.

SOURCE: DoD awards and applications database.





**FIGURE 2-11** Distribution of Phase I SBIR awards among woman-owned small businesses (WOSB), FY2002-2011.  
SOURCE: DoD awards and applications database.

**TABLE 2-4** Top 20 WOSB SBIR/STTR Awardees, FY2002-2011

Company Name	Number of Awards	Total Amount Awarded (Dollars)
Physical Optics	325	30,767,174
Intelligent Automation	269	25,067,179
CFD Research	107	10,219,627
Cybernet Systems	63	6,107,428
First RF	52	5,209,574
21st Century Technologies	43	4,201,388
NAVSYS	38	3,663,344
Technology Assessment & Transfer	37	3,402,382
Composite Technology Development	35	3,145,330
UES Technologies	35	3,361,153
21st Century Systems	32	3,033,488
Touchstone Research Laboratory Ltd.	32	2,698,160
Williams-Pyro	31	2,718,785
Ridgetop Group	26	2,601,288
Polaris Sensor Technologies	25	2,452,270
Pikewerks	23	2,283,363
New Span Opto-Technology	22	1,945,801
MP Technologies	21	2,004,461
Nu-Trek	21	2,038,348
Management Sciences	21	2,019,714
Top 20 WOSBs—total	1,258	118,940,257
All WOSBs—total	2,963	282,087,120
All Phase I awards FY2002-2011	23,224	2,222,884,156
Top 20 WOSBs (percent of total)	5.4%	5.4%
All WOSBs (percent of total)	12.8%	12.7%

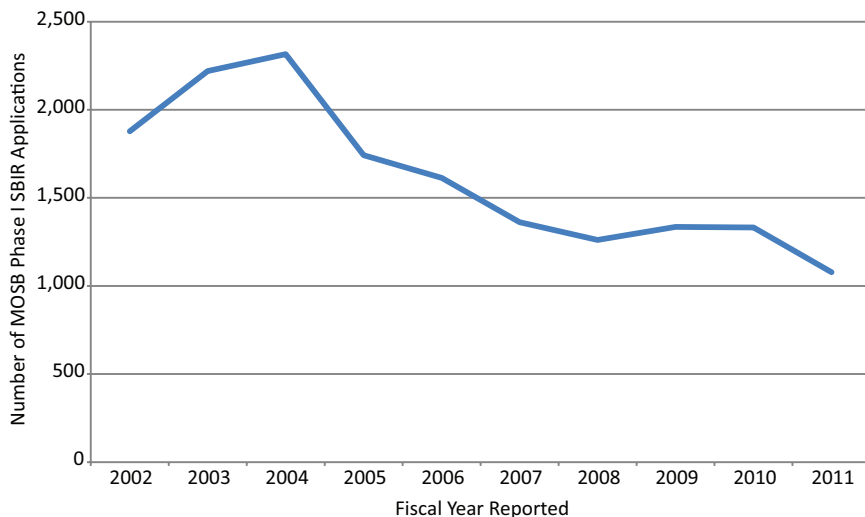
SOURCE: Data provided by DoD.

### Minority-owned Small Businesses (MOSB)

The number of Phase I applications by MOSBs declined steadily from a peak of more than 2,300 in FY2004 to a little more than 1,000 in FY2011 (see Figure 2-12). This decline mirrors the overall decline in applications experienced at DoD during the study period (see Figure 2-13).

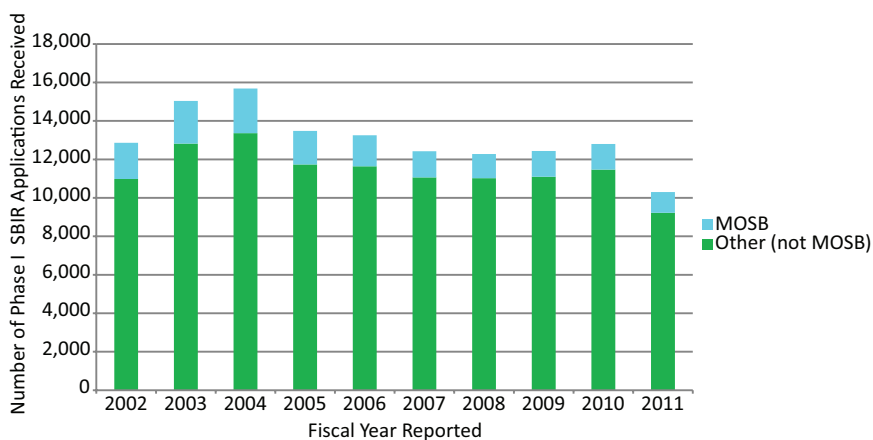
Figure 2-14 summarizes awards to MOSBs by the different components (excluding components that provided less than 100 awards total to MOSBs). There was substantial variation over time, in particular at Army, as well as a long-term decline at MDA.

As with WOSBs (and indeed all awards), awards were concentrated in specific companies. Table 2-5 shows that the top 20 MOSB awardees accounted for about 2.4 percent of all awards and 28 percent of MOSB awards.



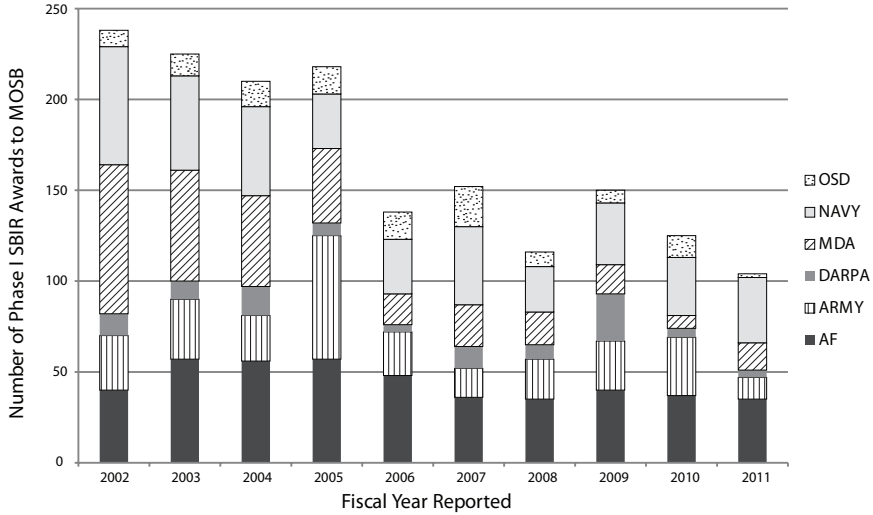
**FIGURE 2-12** Phase I SBIR applications from minority-owned small businesses (MOSB), FY2002-2011.

SOURCE: DoD awards and applications database.



**FIGURE 2-13** Phase I SBIR applications by minority-owned small businesses (MOSB) and Other Companies, FY2002-2011.

SOURCE: DoD awards and applications database.



**FIGURE 2-14** Phase I SBIR awards to minority-owned small businesses (MOSB) by component, FY2002-2011.

NOTE: DoD data for WOSB and MOSB are intrinsically inaccurate. Each record reports which boxes the company checked when applying, and agency staff acknowledge that companies sometimes fail to check an appropriate box. In addition, companies do move in and out of WOSB and MOSB status as they grow.

SOURCE: DoD awards and applications database.

**TABLE 2-5** Phase I SBIR/STTR Awards to MOSBs, FY2002-2011

Company Name	Number of Awards	Total SBIR Phase I Funding (Dollars)
Scientific Systems	56	5,422,967
Agiltron	46	4,431,760
Cybernet Systems	44	4,267,507
Nextgen Aeronautics	38	3,769,054
Scientific Systems	38	3,365,891
Aerius Photonics	36	3,547,566
Agave Biosystems	35	3,297,911
Intelligent Systems Technology	29	2,867,371
American GNC	27	2,474,936
Edaptive Computing	25	2,438,248
Materials Modification	23	1,887,015
SVT Electronics	23	1,944,899
Hypercomp	22	2,407,524
Acellent Technologies	21	2,006,690
Datasoft	19	1,609,881
Wright Materials Research	18	1,649,791
Ceramatec	17	1,585,321
Composite Technology Development	17	1,486,037
Genex Technologies	16	1,497,975
Applied Technology	15	1,362,104
Top 20 MOSBs	565	53,320,448
All MOSBs	2,003	187,202,401
All Phase I awards	23,224	2,222,884,156
Top 20 MOSBs (percent of total awards)	2.4%	2.4%
Top 20 MOSBs (percent of MOSB awards)	28.2%	28.5%

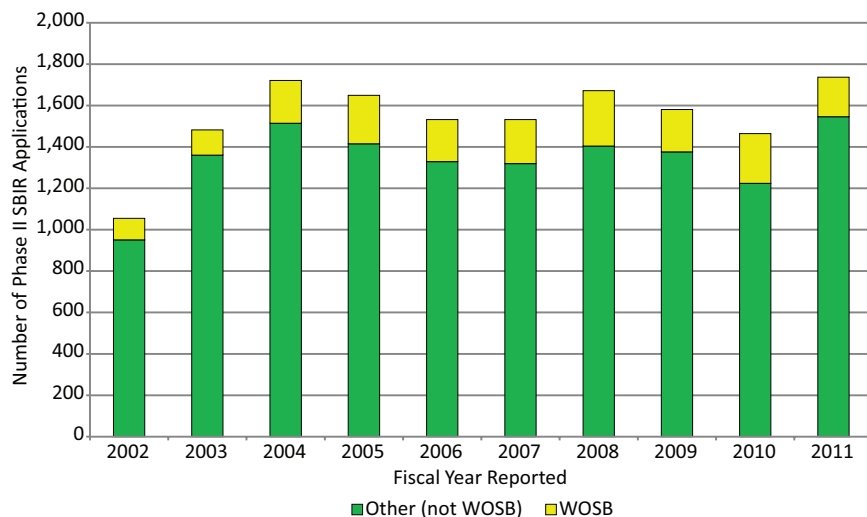
SOURCE: DoD awards and applications database.

### Phase II SBIR Award Demographics<sup>3</sup>

#### Woman-owned Small Businesses

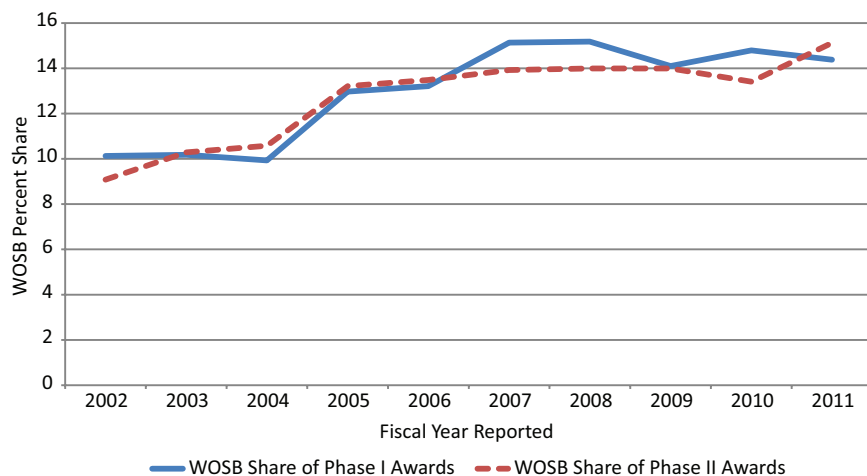
As with SBIR Phase I, the number of Phase II applications received from WOSBs remained largely flat across the study period, averaging 12.5 percent of applications annually (compared to 15.9 percent of Phase I applications) (see Figure 2-21). This stable level of applications is largely matched by a stable level of Phase II awards to WOSBs. The share of Phase II awards to WOSBs remained flat at about 14 percent after FY2005 (see Figure 2-22).

<sup>3</sup> The following text relating to Phase II awards appears on pp. 46-51 of National Research Council, *SBIR at the Department of Defense*, op. cit. Tables 2-8 and 2-9 have been removed from this excerpt because they do not relate to the quoted text.



**FIGURE 2-21** Phase II SBIR applications by woman-owned small businesses (WOSB), FY2002-2011.

SOURCE: DoD awards and applications database.



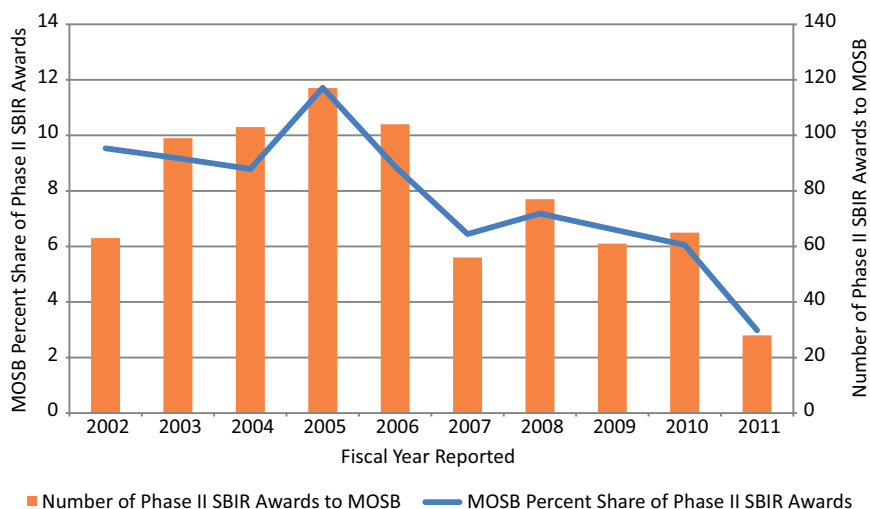
**FIGURE 2-22** Woman-owned small business (WOSB) shares of Phase I and Phase II SBIR awards, FY2002-2011.

SOURCE: DoD awards database; DoD SBIR website, accessed August 15, 2013. <http://www.acq.osd.mil/osbp/sbir/>.

## Minority-owned Small Businesses

The basic data for SBIR Phase II awards to MOSBs reveal very low levels of awards throughout the study period, with a sharp decline in more recent years (see Figure 2-23). On average, MOSBs accounted for 7.8 percent of Phase II SBIR awards, with a peak of 11.5 percent in 2008 to a known low of 6 percent in 2010. According to DoD's data contractor, some inconsistencies remain in the recording of WOSB and MOSB awards at DoD, and the data for 2011 in particular are currently being revised. In part, this decline reflects a decline in the number of Phase II applications by MOSBs (see Figure 2-24).

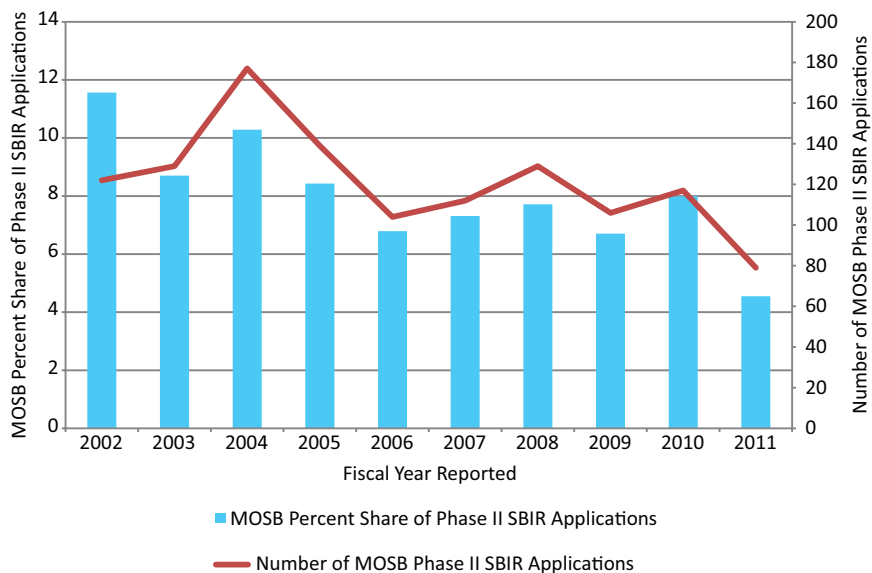
Figure 2-25 compares Phase II application and award rates for MOSBs. Overall, rates are closely aligned: across the entire study period, MOSBs submitted 7.8 percent of the applications and received 7.9 percent of the awards.<sup>4</sup> These results suggest that efforts to expand the number of Phase II awards to MOSBs should focus on encouraging more applications.



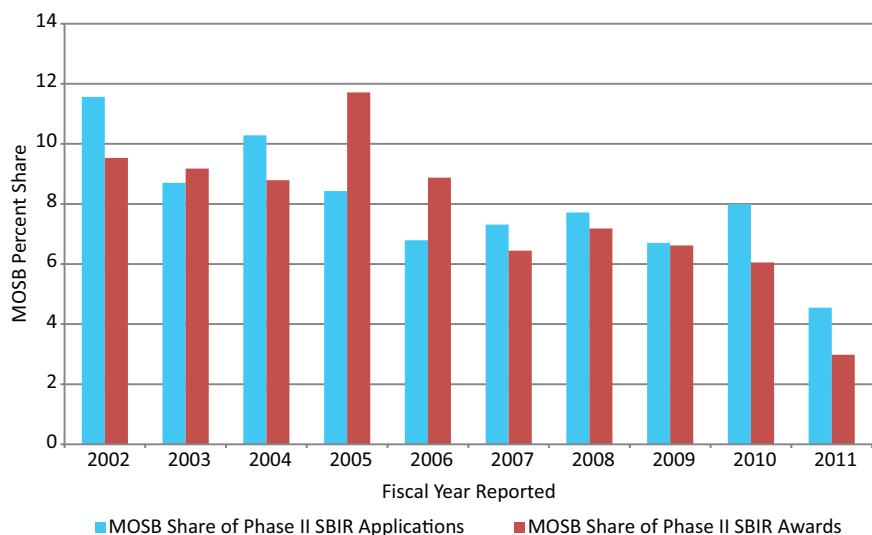
**FIGURE 2-23** Phase II SBIR awards to minority-owned small businesses (MOSB), FY2002-2011.

SOURCE: DoD awards and applications database.

<sup>4</sup> DoD awards and applications databases.



**FIGURE 2-24** Phase II SBIR applications by minority-owned small businesses (MOSB), FY2002-2011.  
 SOURCE: DoD awards and applications database.



**FIGURE 2-25** Phase II SBIR minority-owned small businesses (MOSB) share of awards and applications, FY2002-2011.  
 SOURCE: DoD awards and applications database.





## Appendix D

### Bibliography

- Acs, Z., and D. Audretsch. 1988. "Innovation in Large and Small Firms: An Empirical Analysis." *The American Economic Review* 78(4):678-690.
- Acs, Z., and D. Audretsch. 1990. *Innovation and Small Firms*. Cambridge, MA: MIT Press.
- Adelstein, F. 2006. "Live Forensics: Diagnosing Your System Without Killing It First," <http://frank.notfrank.com/Papers/CACM06.pdf>. Accessed July 17, 2014.
- Advanced Technology Program. 2001. *Performance of 50 Completed ATP Projects, Status Report 2*. National Institute of Standards and Technology Special Publication 950-2. Washington, DC: Advanced Technology Program/National Institute of Standards and Technology/U.S. Department of Commerce.
- Alic, J. 1987. "Evaluating Competitiveness at the Office of Technology Assessment." *Technology in Society* 9(1):1-17. For a review of how these issues emerged and evolved within the context of a series of analyses at a Congressional agency.
- Alic, J. A., L. Branscomb, H. Brooks, A. B. Carter, and G. L. Epstein. 1992. *Beyond Spinoff: Military and Commercial Technologies in a Changing World*. Boston, MA: Harvard Business School Press.
- American Association for the Advancement of Science. "R&D Funding Update on NSF in the FY2007," <http://www.aaas.org/spp/rd/nsf07hf1.pdf>.
- American Psychological Association. 2002. "Criteria for Evaluating Treatment Guidelines." *American Psychologist* 57(12):1052-1059.
- Archibald, R., and D. Finifter. 2000. "Evaluation of the Department of Defense Small Business Innovation Research Program and the Fast Track Initiative: A Balanced Approach." In National Research Council. *The Small Business Innovation Research Program: An Assessment of the Department of Defense Fast Track Initiative*. Washington, DC: National Academy Press.
- Archibald, R., and D. Finifter. 2003. "Evaluating the NASA Small Business Innovation Research Program: Preliminary Evidence of a Tradeoff Between Commercialization and Basic Research." *Research Policy* 32:605-619.
- Archibugi, D., A. Filippetti, and M. Frenz. 2013. "Economic Crisis and Innovation: Is Destruction Prevailing Over Accumulation?" *Research Policy* 42(2):303-314.

- Arrow, K. 1962. "Economic Welfare and the Allocation of Resources for Invention." Pp. 609-625 in *The Rate and Direction of Inventive Activity: Economic and Social Factors*. Princeton, NJ: Princeton University Press.
- Arrow, K. 1973. "The Theory of Discrimination." Pp. 3-31 in *Discrimination in Labor Market*. O. Ashenfelter and A. Rees, eds. Princeton, NJ: Princeton University Press.
- Audretsch, D. B. 1995. *Innovation and Industry Evolution*. Cambridge, MA: MIT Press.
- Audretsch, D. B., and M. P. Feldman. 1996. "R&D Spillovers and the Geography of Innovation and Production." *American Economic Review* 86(3):630-640.
- Audretsch, D. B., and P. E. Stephan. 1996. "Company-scientist Locational Links: The Case of Biotechnology." *American Economic Review* 86(3):641-642.
- Audretsch, D., and R. Thurik. 1999. *Innovation, Industry Evolution, and Employment*. Cambridge, MA: MIT Press.
- Audretsch, D., J. Weigand, and C. Weigand. 2000. "Does the Small Business Innovation Research Program Foster Entrepreneurial Behavior." In National Research Council. *The Small Business Innovation Research Program: An Assessment of the Department of Defense Fast Track Initiative*. Washington, DC: The National Academies Press.
- Baker, A. No date. "Commercialization Support at NSF." Draft.
- Baker, J. A. K., and K. J. Thurber. 2011. *Developing Computer Systems Requirements*. Ithaca, NY: Digital Systems Press.
- Barfield, C., and W. Schambra, eds. 1986. *The Politics of Industrial Policy*. Washington, DC: American Enterprise Institute for Public Policy Research.
- Barry, C. B. 1994. "New Directions in Research on Venture Capital Finance." *Financial Management* 23 (Autumn):3-15.
- Baron, J. 1998. "DoD SBIR/STTR Program Manager." Comments at the Methodology Workshop on the Assessment of Current SBIR Program Initiatives, Washington, DC, October.
- Bator, F. 1958. "The Anatomy of Market Failure." *Quarterly Journal of Economics* 72:351-379.
- Biemer, P. P., and L. E. Lyberg. 2003. *Introduction to Survey Quality*. New York: John Wiley & Sons.
- Bingham, R. 1998. *Industrial Policy American Style: From Hamilton to HDTV*. New York: M.E. Sharpe.
- Birch, D. 1981. "Who Creates Jobs." *The Public Interest* 65 (Fall):3-14.
- Branscomb, L. M., and P. E. Auerswald. 2001. *Taking Technical Risks: How Innovators, Managers, and Investors Manage Risk in High-Tech Innovations*, Cambridge, MA: MIT Press.
- Branscomb, L. M., and P. E. Auerswald. 2002. *Between Invention and Innovation: An Analysis of Funding for Early-Stage Technology Development*. Gaithersburg, MD: National Institute of Standards and Technology.
- Branscomb, L. M., and P. E. Auerswald. 2003. "Valleys of Death and Darwinian Seas: Financing the Invention to Innovation Transition in the United States." *The Journal of Technology Transfer* 28(3-4).
- Branscomb, L. M., and J. Keller. 1998. *Investing in Innovation: Creating a Research and Innovation Policy*. Cambridge, MA: MIT Press.
- Branscomb, L. M., K. P. Morse, M. J. Roberts, and D. Boville. 2000. *Managing Technical Risk: Understanding Private Sector Decision-Making on Early Stage Technology Based Projects*. Washington, DC: Department of Commerce/National Institute of Standards and Technology.
- Brav, A., and P. A. Gompers. 1997. "Myth or Reality?: Long-Run Underperformance of Initial Public Offerings; Evidence from Venture capital and Nonventure Capital-Backed IPOs." *Journal of Finance* 52:1791-1821.
- Bouchie, A. 2003. "Increasing Number of Companies Found Ineligible for SBIR Funding," *Nature Biotechnology* 21(10):1121-1122.
- Brodd, R. J. 2005. *Factors Affecting U.S. Production Decisions: Why Are There No Volume Lithium-Ion Battery Manufacturers in the United States?* ATP Working Paper No. 05-01, June.
- Brown, G., and J. Turner. 1999. "Reworking the Federal Role in Small Business Research." *Issues in Science and Technology* XV, 4 (Summer).

- Bush, V. 1946. *Science—the Endless Frontier*. Republished in 1960 by U.S. National Science Foundation, Washington, DC.
- Cahill, P. 2000. “Fast Track: Is it Speeding Commercialization of Department of Defense Small Business Innovation Research Projects?” In National Research Council. *The Small Business Innovation Research Program: An Assessment of the Department of Defense Fast Track Initiative*. Washington, DC: National Academy Press.
- Carden, S. D., and O. Darragh. 2004. “A Halo for Angel Investors.” *The McKinsey Quarterly* 1.
- Cassell, G. 2004. “Setting Realistic Expectations for Success.” In National Research Council. *SBIR: Program Diversity and Assessment Challenges*. Washington, DC: The National Academies Press.
- Caves, R. E. 1998. “Industrial Organization and New Findings on the Turnover and Mobility of Firms.” *Journal of Economic Literature* 36(4):1947-1982.
- Christensen, C. 1997. *The Innovator’s Dilemma*. Boston, MA: Harvard Business School Press.
- Christensen, C., and M. Raynor. 2003. *Innovator’s Solution*, Boston, MA: Harvard Business School.
- Clabaugh, J. 2012. “TRX Systems Gets \$2M in VC Funding.” *Washington Business Journal*.
- Clinton, W. J. 1994. *Economic Report of the President*. Washington, DC: U.S. Government Printing Office.
- Clinton, W. J. 1994. *The State of Small Business*. Washington, DC: U.S. Government Printing Office.
- Coburn, C., and D. Bergland. 1995. *Partnerships: A Compendium of State and Federal Cooperative Technology Programs*. Columbus, OH: Battelle.
- Cochrane, J. H. 2005. “The Risk and Return of Venture Capital.” *Journal of Financial Economics* 75(1):3-52.
- Cohen, L. R., and R. G. Noll. 1991. *The Technology Pork Barrel*. Washington, DC: The Brookings Institution.
- Congressional Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development. 2000. *Land of Plenty: Diversity as America’s Competitive Edge in Science, Engineering and Technology*. Washington, DC: National Science Foundation/U.S. Government Printing Office.
- Cooper, R. G. 2001. “Winning at New Products: Accelerating the Process from Idea to Launch.” In Dawnbreaker, Inc. 2005. “The Phase III Challenge: Commercialization Assistance Programs 1990-2005.” White paper. July 15.
- Council of Economic Advisers. 1995. *Supporting Research and Development to Promote Economic Growth: The Federal Government’s Role*. Washington, DC.
- Council on Competitiveness. 2005. *Innovate America: Thriving in a World of Challenge and Change*. Washington, DC: Council on Competitiveness.
- Cramer, R. 2000. “Patterns of Firm Participation in the Small Business Innovation Research Program in Southwestern and Mountain States.” In National Research Council. 2000. *The Small Business Innovation Research Program: An Assessment of the Department of Defense Fast Track Initiative*. Washington, DC: National Academy Press.
- Crane, G., and J. Sohl. 2004. “Imperatives for Venture Success: Entrepreneurs Speak.” *The International Journal of Entrepreneurship and Innovation* (May):99-106.
- Cutler, D. 2005. *Your Money or Your Life*. New York: Oxford University Press.
- Cycyota, C. S., and D. A. Harrison. 2006. “What (Not) to Expect When Surveying Executives: A Meta-Analysis of Top Manager Response.” *Organizational Research Methods* 9:133-160.
- Czarnitzki, D., and A. Fier. 2002. “Do Innovation Subsidies Crowd out Private Investment? Evidence from the German Service Sector.” ZEW Discussion Papers, No. 02-04.
- Dalton, A. B., S. Collins, E. Muñoz, J. Razall, V. H. Ebron, J. Ferraris, J. Coleman, B. Kim, and R. Baughman. 2003. “Super-tough Carbon-nanotube Fibres.” *Nature* 423(4):703.
- David, P. A., B. H. Hall, and A. A. Tool. 1999. “Is Public R&D a Complement or Substitute for Private R&D? A Review of the Econometric Evidence.” NBER Working Paper 7373. October.
- Davidsson, P. 1996. “Methodological Concerns in the Estimation of Job Creation in Different Firm Size Classes.” Working Paper. Jönköping International Business School.

- Davis, S. J., J. Haltiwanger, and S. Schuh. 1994. "Small Business and Job Creation: Dissecting the Myth and Reassessing the Facts," *Business Economics* 29(3):113-122.
- Dawnbreaker, Inc. 2005. "The Phase III Challenge: Commercialization Assistance Programs 1990-2005." White paper. July 15.
- Dertouzos, M. L. 1989. *Made in America: The MIT Commission on Industrial Productivity*. Cambridge, MA: MIT Press.
- Dertouzos, M. L., R. Lester, and R. Solow. 1989. *Made in America: The MIT Commission on Industrial Productivity*. Cambridge, MA: The MIT Press.
- Dess, G. G., and D. W. Beard. 1984. "Dimensions of Organizational Task Environments." *Administrative Science Quarterly* 29:52-73.
- Devenow, A., and I. Welch. 1996. "Rational Herding in Financial Economics." *European Economic Review* 40(April):603-615.
- Dillman, D. 2000. *Mail and Internet Surveys: The Tailored Design Method*. 2nd Edition. Toronto, Ontario: John Wiley and Sons, Inc.
- DoE Opportunity Forum. 2005. "Partnering and Investment Opportunities for the Future." Tysons Corner, VA. October 24-25.
- Eckstein, O. 1984. *DRI Report on U.S. Manufacturing Industries*. New York: McGraw Hill.
- Eisinger, P. K. 1988. *The Rise of the Entrepreneurial State: State and Local Economic Development Policy in the United States*. Madison, WI: University of Wisconsin Press.
- Ernst and Young. 2007. "U.S. Venture Capital Investment Increases to 8 percent to \$6.96 Billion in First Quarter of 2007." April 23.
- Evenson, R., P. Waggoner, and P. Ruttan. 1979. "Economic Benefits from Research: An Example from Agriculture," *Science* 205(14 September):1101-1107.
- Feldman, M. P. 1994. *The Geography of Knowledge*. Boston, MA: Kluwer Academic.
- Feldman, M. P. 1994. "Knowledge Complementarity and Innovation." *Small Business Economics* 6(5):363-372.
- Feldman, M. P. 2000. "Role of the Department of Defense in Building Biotech Expertise." In National Research Council. *The Small Business Innovation Research Program: An Assessment of the Department of Defense Fast Track Initiative*. Washington, DC: The National Academies Press.
- Feldman, M. P. 2001. "Assessing the ATP: Halo Effects and Added Value." In National Research Council. *The Advanced Technology Program: Assessing Outcomes*. Washington, DC: National Academy Press.
- Feldman, M. P., and M. R. Kelley. 2001. "Leveraging Research and Development: The Impact of the Advanced Technology Program." In National Research Council. *The Advanced Technology Program*. Washington, DC: National Academy Press.
- Feldman, M. P., and M. R. Kelley. 2001. *Winning an Award from the Advanced Technology Program: Pursuing R&D Strategies in the Public Interest and Benefiting from a Halo Effect*. NISTIR 6577. Washington, DC: Advanced Technology Program/National Institute of Standards and Technology/U.S. Department of Commerce.
- Fenn, G. W., N. Liang, and S. Prowse. 1995. *The Economics of the Private Equity Market*. Washington, DC: Board of Governors of the Federal Reserve System.
- Financial Times*. 2004. "Qinetiq Set to Make Its First US Acquisition." September 8.
- Fischer, E., and A. R. Reuber. 2003. "Support for Rapid-growth Firms: A comparison of the Views of Founders, Government Policymakers, and Private Sector Resource Providers." *Journal of Small Business Management* 41(4):346-365.
- Flamm, K. 1988. *Creating the Computer*. Washington, DC: The Brookings Institution.
- Flender, J. O., and R. S. Morse. 1975. *The Role of New Technical Enterprise in the U.S. Economy*. Cambridge, MA: MIT Development Foundation.
- Freear, J., and W. E. Wetzel Jr. 1990. "Who Bankrolls High-tech Entrepreneurs?" *Journal of Business Venturing* 5:77-89.
- Freeman, C., and L. Soete. 1997. *The Economics of Industrial Innovation*. Cambridge, MA: MIT Press.

- Galbraith, J. K. 1957. *The New Industrial State*. Boston: Houghton Mifflin.
- Gallagher, S. 2012. "Here Come the Inflate-a-Bots: iRobot's AIR Blow Up Bot Prototypes." *ARS Technica*.
- Geroski, P. A. 1995. "What Do We Know About Entry?" *International Journal of Industrial Organization* 13(4):421-440.
- Geshwiler, J., J. May, and M. Hudson. 2006. *State of Angel Groups*. Kansas City, MO: Kauffman Foundation.
- Gompers, P. A. 1995. "Optimal Investment, Monitoring, and the Staging of Venture Capital." *Journal of Finance* 50:1461-1489.
- Gompers, P. A., and J. Lerner. 1977. "Risk and Reward in Private Equity Investments: The Challenge of Performance Assessment." *Journal of Private Equity* 1:5-12.
- Gompers, P. A., and J. Lerner. 1996. "The Use of Covenants: An Empirical Analysis of Venture Partnership Agreements." *Journal of Law and Economics* 39:463-498.
- Gompers, P. A., and J. Lerner. 1998. "Capital Formation and Investment in Venture Markets: A Report to the NBER and the Advanced Technology Program." Unpublished working paper. Harvard University.
- Gompers, P. A., and J. Lerner. 1998. "What Drives Venture Capital Fund-Raising?" Unpublished working paper. Harvard University.
- Gompers, P. A., and J. Lerner. 1999. "An Analysis of Compensation in the U.S. Venture Capital Partnership." *Journal of Financial Economics* 51(1):3-7.
- Gompers, P. A., and J. Lerner. 1999. *The Venture Cycle*. Cambridge, MA: MIT Press.
- Good, M. L. 1995. Prepared testimony before the Senate Commerce, Science, and Transportation Committee, Subcommittee on Science, Technology, and Space (photocopy, U.S. Department of Commerce).
- Goodnight, J. 2003. Presentation at National Research Council Symposium. "The Small Business Innovation Research Program: Identifying Best Practice." Washington, DC, May 28.
- Graham, O. L. 1992. *Losing Time: The Industrial Policy Debate*. Cambridge, MA: Harvard University Press.
- Greenwald, B. C., J. E. Stiglitz, and A. Weiss. 1984. "Information Imperfections in the Capital Market and Macroeconomic Fluctuations." *American Economic Review Papers and Proceedings* 74:194-199.
- Griliches, Z. 1990. *The Search for R&D Spillovers*. Cambridge, MA: Harvard University Press.
- Groves, R. M., D. A. Dillman, J. L. Eltinge, and R. J. A. Little, eds. 2002. *Survey Nonresponse*. New York: Wiley.
- Groves, R. M., F. J. Fowler, Jr., M. P. Couper, J. M. Lepkowski, E. Singer, and R. Tourangeau. 2004. *Survey Methodology*. Hoboken, NJ: John Wiley & Sons, Inc.
- Haltiwanger, J., and C. J. Krizan. 1999. "Small Businesses and Job Creation in the United States: The Role of New and Young Businesses." In *Are Small Firms Important? Their Role and Impact*, Z. J. Acs, ed. Dordrecht: Kluwer.
- Hamberg, D. 1963. "Invention in the Industrial Research Laboratory." *Journal of Political Economy* (April):95-115.
- Hao, K. Y., and A. B. Jaffe. 1993. "Effect of Liquidity on Firms' R&D spending." *Economics of Innovation and New Technology* 2:275-282.
- Hebert, R. F., and A. N. Link. 1989. "In Search of the Meaning of Entrepreneurship." *Small Business Economics* 1(1):39-49.
- Heilman, C. 2005. "Partnering for Vaccines: The NIAID Perspective." In *Partnering Against Terrorism: Summary of a Workshop*. Washington, DC: The National Academies Press.
- Held, B., T. Edison, S. L. Pfeeger, P. Anton, and J. Clancy. 2006. *Evaluation and Recommendations for Improvement of the Department of Defense Small Business Innovation Research (SBIR) Program*. Arlington, VA: RAND National Defense Research Institute.
- Henrekson, M., and D. Johansson. 2009. "Competencies and Institutions Fostering High-Growth Firms." *Foundations and Trends in Entrepreneurship* 5(1):1-80.

- Himmelberg, C. P., and B. C. Petersen. 1994. "R&D and Internal Finance: A Panel Study of Small Firms in High-Tech Industries." *Review of Economics and Statistics* 76:38-51.
- Holland, C. 2007. "Meeting Mission Needs." In National Research Council. *SBIR and the Phase III Challenge of Commercialization*. Washington, DC: The National Academies Press.
- Hong, S., and S. Myung. 2007. "Nanotube Electronics: A Flexible Approach to Obesity." *Nature Nanotechnology* 2(4):207-208.
- Hubbard, R. G. 1998. "Capital-market Imperfections and Investment." *Journal of Economic Literature* 36:193-225.
- Huntsman, B., and J. P. Hoban Jr. 1980. "Investment in New Enterprise: Some Empirical Observations on Risk, Return, and Market Structure." *Financial Management* 9 (Summer):44-51.
- IDC. 2011. Digital Universe 2011, "Extracting Value from Chaos," <http://www.emc.com/leadership/programs/digital-universe.htm>.
- Institute of Medicine. 1998. "The Urgent Need to Improve Health Care Quality." National Roundtable on Health Care Quality. *Journal of the American Medical Association* 280(11):1003, September 16.
- Jacobs, T. 2002. "Biotech Follows Dot.com Boom and Bust." *Nature* 20(10):973.
- Jaffe, A. B. 1996. *Economic Analysis of Research Spillovers: Implications for the Advanced Technology Program*. Washington, DC: Advanced Technology Program/National Institute of Standards and Technology/U.S. Department of Commerce).
- Jaffe, A. B. 1998. "The Importance of 'Spillovers' in the Policy Mission of the Advanced Technology Program." *Journal of Technology Transfer* (Summer).
- Jarboe, K. P., and R. D. Atkinson. 1998. *The Case for Technology in the Knowledge Economy: R&D, Economic Growth and the Role of Government*. Washington, DC: Progressive Policy Institute. <http://www.ppionline.org/documents/CaseforTech.pdf>.
- Jewkes, J., D. Sawers, and R. Stillerman. 1958. *The Sources of Invention*. New York: St. Martin's Press.
- Johnson, M. 2004. "SBIR at the Department of Energy: Achievements, Opportunities, and Challenges." In National Research Council. *SBIR: Program Diversity and Assessment Challenges*. Washington, DC: The National Academies Press.
- Johnson, W. 2004. "Delivering Combat Power to the Fleet." *Naval Engineers Journal* (Fall):3-5.
- Johnson, T., and L. Owens. 2003. "Survey Response Rate Reporting in the Professional Literature." Paper presented at the 58th Annual Meeting of the American Association for Public Opinion Research. Nashville, TN. May.
- Kaplowitz, M. D., T. D. Hadlock, and R. Levine. 2004. "A Comparison of Web and Mail Survey Response Rates." *Public Opinion Quarterly* 68(1):94-101.
- Kauffman Foundation. 2014. "About the Foundation," <http://www.kauffman.org/foundation.cfm>.
- Kleinman, D. L. 1995. *Politics on the Endless Frontier: Postwar Research Policy in the United States*. Durham, NC: Duke University Press.
- Kolosnjaj, J., H. Szwarc, and F. Moussa. 2007. "Toxicity Studies of Carbon Nanotubes." *Advances in Experimental Medicine and Biology* 620:181-204.
- Kortum, S., and J. Lerner. 1998. "Does Venture Capital Spur Innovation?" NBER Working Paper No. 6846, National Bureau of Economic Research.
- Krugman, P. 1990. *Rethinking International Trade*. Cambridge, MA: MIT Press.
- Krugman, P. 1991. *Geography and Trade*. Cambridge, MA: MIT Press.
- Langlois, R. N. 2001. "Knowledge, Consumption, and Endogenous Growth." *Journal of Evolutionary Economics* 11:77-93.
- Langlois, R. N., and P. L. Robertson. 1996. "Stop Crying over Spilt Knowledge: A Critical Look at the Theory of Spillovers and Technical Change." Paper prepared for the MERIT Conference on Innovation, Evolution, and Technology. Maastricht, Netherlands, August 25-27.
- Lebow, I. 1995. *Information Highways and Byways: From the Telegraph to the 21st Century*. New York: Institute of Electrical and Electronic Engineering.
- Lerner, J. 1994. "The Syndication of Venture Capital Investments." *Financial Management* 23-(Autumn):16-27.

- Lerner, J. 1995. "Venture Capital and the Oversight of Private Firms." *Journal of Finance* 50:301-318.
- Lerner, J. 1996. "The Government as Venture Capitalist: The Long-run Effects of the SBIR Program." Working Paper No. 5753, National Bureau of Economic Research.
- Lerner, J. 1998. "Angel Financing and Public Policy: An Overview." *Journal of Banking and Finance* 22(6-8):773-784.
- Lerner, J. 1999. "The Government as Venture Capitalist: The Long-run Effects of the SBIR Program." *Journal of Business* 72(3):285-297.
- Lerner, J. 1999. "Public Venture Capital: Rationales and Evaluation." In National Research Council. *The SBIR Program: Challenges and Opportunities*. Washington, DC: National Academy Press.
- Levy, D. M., and N. Terleckyyk. 1983. "Effects of Government R&D on Private R&D Investment and Productivity: A Macroeconomic Analysis." *Bell Journal of Economics* 14:551-561.
- Liles, P. 1977. *Sustaining the Venture Capital Firm*. Cambridge, MA: Management Analysis Center.
- Link, A. N. 1998. "Public/Private Partnerships as a Tool to Support Industrial R&D: Experiences in the United States." Paper prepared for the working group on Innovation and Technology Policy of the OECD Committee for Science and Technology Policy, Paris.
- Link, A. N., and J. Rees. 1990. "Firm Size, University Based Research and the Returns to R&D." *Small Business Economics* 2(1):25-32.
- Link, A. N., and J. T. Scott. 1998. "Assessing the Infrastructural Needs of a Technology-based Service Sector: A New Approach to Technology Policy Planning." *STI Review* 22:171-207.
- Link, A. N., and J. T. Scott. 1998. *Overcoming Market Failure: A Case Study of the ATP Focused Program on Technologies for the Integration of Manufacturing Applications (TIMA)*. Draft final report submitted to the Advanced Technology Program. Gaithersburg, MD: National Institute of Technology. October.
- Link, A. N., and J. T. Scott. 1998. *Public Accountability: Evaluating Technology-Based Institutions*. Norwell, MA: Kluwer Academic.
- Link, A. N., and J. T. Scott. 2005. *Evaluating Public Research Institutions: The U.S. Advanced Technology Program's Intramural Research Initiative*. London: Routledge.
- Longini, P. 2003. "Hot Buttons for NSF SBIR Research Funds." Pittsburgh Technology Council. *TechyVent*. November 27.
- Malone, T. 1995. *The Microprocessor: A Biography*. Hamburg, Germany: Springer Verlag/Telos.
- Mankins, John C. 1995. *Technology Readiness Levels: A White Paper*. Washington, DC: NASA Office of Space Access and Technology. Advanced Concepts Office.
- Mann, D., Q. Wang, K. Goodson, and H. Dai. 2005. "Thermal Conductance of an Individual Single-wall Carbon Nanotube Above Room Temperature." *Nano Letters* 6(1):96-100.
- Mansfield, E. 1985. "How Fast Does New Industrial Technology Leak Out?" *Journal of Industrial Economics* 34(2).
- Mansfield, E. 1996. *Estimating Social and Private Returns from Innovations Based on the Advanced Technology Program: Problems and Opportunities*. Unpublished report.
- Mansfield, E., J. Rapoport, A. Romeo, S. Wagner, and G. Beardsley. 1977. "Social and Private Rates of Return from Industrial Innovations." *Quarterly Journal of Economics* 91:221-240.
- Martin, Justin. 2002. "David Birch." *Fortune Small Business* (December 1).
- McCraw, T. 1986. "Mercantilism and the Market: Antecedents of American Industrial Policy." In C. Barfield and W. Schambra, eds. *The Politics of Industrial Policy*. Washington, DC: American Enterprise Institute for Public Policy Research.
- Mervis, J. D. 1996. "A \$1 Billion 'Tax' on R&D Funds." *Science* 272:942-944.
- Mock, D. 2005. "The Qualcomm Equation: How a Fledgling Telecommunications Company Forged a New Path to Big Profits and Market Dominance." AMACON, p. 91.
- Moore, D. 2004. "Turning Failure into Success." In National Research Council. *The Small Business Innovation Research Program: Program Diversity and Assessment Challenges*. Washington, DC: The National Academies Press.



- Morgenthaler, D. 2000. "Assessing Technical Risk." In L. M. Branscomb, K. P. Morse, and M. J. Roberts, eds. *Managing Technical Risk: Understanding Private Sector Decision Making on Early Stage Technology-Based Project*. Gaithersburg, MD: National Institute of Standards and Technology.
- Mowery, D. 1998. "Collaborative R&D: How Effective Is It?" *Issues in Science and Technology* (Fall):37-44.
- Mowery, D.C. 1999. "America's Industrial Resurgence (?): An Overview" In National Research Council, *U.S. Industry in 2000: Studies in Competitive Performance*. D. C. Mowery, ed. Washington, DC: National Academy Press, p. 1.
- Mowery, D., and N. Rosenberg. 1989. *Technology and the Pursuit of Economic Growth*. New York: Cambridge University Press.
- Mowery, D., and N. Rosenberg. 1998. *Paths of Innovation: Technological Change in 20th Century America*. New York: Cambridge University Press.
- Murphy, L. M., and P. L. Edwards. 2003. *Bridging the Valley of Death—Transitioning from Public to Private Sector Financing*. Golden, CO: National Renewable Energy Laboratory. May.
- Myers, S., R. L. Stern, and M. L. Rorke. 1983. *A Study of the Small Business Innovation Research Program*. Lake Forest, IL: Mohawk Research Corporation.
- Myers, S. C., and N. Majluf. 1984. "Corporate Financing and Investment Decisions When Firms Have Information That Investors Do Not Have." *Journal of Financial Economics* 13:187-221.
- National Aeronautics and Space Administration. 2002. "Small Business/SBIR: NICMOS Cryocooler—Reactivating a Hubble Instrument." *Aerospace Technology Innovation* 10(4):19-21.
- National Aeronautics and Space Administration. 2005. "The NASA SBIR and STTR Programs Participation Guide," <http://sbir.gsfc.nasa.gov/SBIR/zips/guide.pdf>.
- National Institutes of Health. 2003. "Road Map for Medical Research," <http://nihroadmap.nih.gov/>.
- National Institutes of Health. 2005. *Report on the Second of the 2005 Measures Updates: NIH SBIR Performance Outcomes Data System (PODS)*. Bethesda, MD: National Institutes of Health.
- National Research Council. 1986. *The Positive Sum Strategy: Harnessing Technology for Economic Growth*. Washington, DC: National Academy Press.
- National Research Council. 1987. *Semiconductor Industry and the National Laboratories: Part of a National Strategy*. Washington, DC: National Academy Press.
- National Research Council. 1991. *Mathematical Sciences, Technology, and Economic Competitiveness*. J. G. Glimm, ed. Washington, DC: National Academy Press.
- National Research Council. 1992. *The Government Role in Civilian Technology: Building a New Alliance*. Washington, DC: National Academy Press.
- National Research Council. 1995. *Allocating Federal Funds for R&D*. Washington, DC: National Academy Press.
- National Research Council. 1996. *Conflict and Cooperation in National Competition for High-Technology Industry*. Washington, DC: National Academy Press.
- National Research Council. 1997. *Review of the Research Program of the Partnership for a New Generation of Vehicles: Third Report*. Washington, DC: National Academy Press.
- National Research Council. 1999. *The Advanced Technology Program: Challenges and Opportunities*. Washington, DC: National Academy Press.
- National Research Council. 1999. *Funding a Revolution: Government Support for Computing Research*. Washington, DC: National Academy Press.
- National Research Council. 1999. *Industry-Laboratory Partnerships: A Review of the Sandia Science and Technology Park Initiative*. Washington, DC: National Academy Press.
- National Research Council. 1999. *New Vistas in Transatlantic Science and Technology Cooperation*. Washington, DC: National Academy Press.
- National Research Council. 1999. *The Small Business Innovation Research Program: Challenges and Opportunities*. Washington, DC: National Academy Press.
- National Research Council. 2000. *The Small Business Innovation Research Program: An Assessment of the Department of Defense Fast Track Initiative*. Washington, DC: National Academy Press.

- National Research Council. 2000. *U.S. Industry in 2000: Studies in Competitive Performance*. Washington, DC: National Academy Press.
- National Research Council. 2001. *The Advanced Technology Program: Assessing Outcomes*. Washington, DC: National Academy Press.
- National Research Council. 2001. *Attracting Science and Mathematics Ph.D.s to Secondary School Education*. Washington, DC: National Academy Press.
- National Research Council. 2001. *Building a Workforce for the Information Economy*. Washington, DC: National Academy Press.
- National Research Council. 2001. *Capitalizing on New Needs and New Opportunities: Government-Industry Partnerships in Biotechnology and Information Technologies*. Washington, DC: National Academy Press.
- National Research Council. 2001. *A Review of the New Initiatives at the NASA Ames Research Center*. Washington, DC: National Academy Press.
- National Research Council. 2001. *Trends in Federal Support of Research and Graduate Education*. Washington, DC: National Academy Press.
- National Research Council. 2002. *Government-Industry Partnerships for the Development of New Technologies: Summary Report*. Washington, DC: The National Academies Press.
- National Research Council. 2002. *Making the Nation Safer: The Role of Science and Technology in Countering Terrorism*. Washington, DC: The National Academies Press.
- National Research Council. 2002. *Measuring and Sustaining the New Economy*. D. W. Jorgenson and C. W. Wessner, eds. Washington, DC: National Academy Press.
- National Research Council. 2002. *Partnerships for Solid-State Lighting*. Washington, DC: The National Academies Press.
- National Research Council. 2004. *An Assessment of the Small Business Innovation Research Program: Project Methodology*. Washington, DC: The National Academies Press.
- National Research Council. 2004. *Productivity and Cyclicalities in Semiconductors: Trends, Implications, and Questions*. D. W. Jorgenson and C. W. Wessner, eds. Washington, DC: The National Academies Press.
- National Research Council. 2004. *SBIR—Program Diversity and Assessment Challenges: Report of a Symposium*. Washington, DC: The National Academies Press.
- National Research Council. 2004. *The Small Business Innovation Research Program: Program Diversity and Assessment Challenges*. Washington, DC: The National Academies Press.
- National Research Council. 2006. *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering*. Washington, DC: The National Academies Press.
- National Research Council. 2006. *Deconstructing the Computer*. D. W. Jorgenson and C. W. Wessner, eds. Washington, DC: The National Academies Press.
- National Research Council. 2006. *Software, Growth, and the Future of the U.S. Economy*. D. W. Jorgenson and C. W. Wessner, eds. Washington, DC: The National Academies Press.
- National Research Council. 2006. *The Telecommunications Challenge: Changing Technologies and Evolving Policies*. D. W. Jorgenson and C. W. Wessner, eds. Washington, DC: The National Academies Press.
- National Research Council. 2007. *Enhancing Productivity Growth in the Information Age: Measuring and Sustaining the New Economy*. D. W. Jorgenson and C. W. Wessner, eds. Washington, DC: The National Academies Press.
- National Research Council. 2007. *India's Changing Innovation System: Achievements, Challenges, and Opportunities for Cooperation*. C. W. Wessner and S. J. Shivakumar, eds. Washington, DC: The National Academies Press.
- National Research Council. 2007. *Innovation Policies for the 21st Century*. Washington, DC: The National Academies Press.
- National Research Council. 2007. *SBIR and the Phase III Challenge of Commercialization*. Washington, DC: The National Academies Press.

- National Research Council. 2008. *An Assessment of the SBIR Program at the Department of Defense*. Washington, DC: The National Academies Press.
- National Research Council. 2008. *An Assessment of the SBIR Program at the Department of Energy*. Washington, DC: The National Academies Press.
- National Research Council. 2008. *An Assessment of the SBIR Program at the National Science Foundation*. Washington, DC: The National Academies Press.
- National Research Council. 2009. *An Assessment of the SBIR Program at the Department of Defense*. Washington, DC: The National Academies Press.
- National Research Council. 2009. *An Assessment of the SBIR Program at the National Aeronautics and Space Administration*. Washington, DC: The National Academies Press.
- National Research Council. 2009. *An Assessment of the SBIR Program at the National Institutes of Health*. Washington, DC: The National Academies Press.
- National Research Council. 2009. *Revisiting the Department of Defense SBIR Fast Track Initiative*. Washington, DC: The National Academies Press.
- National Research Council. 2009. *Venture Capital and the NIH SBIR Program*. Washington, DC: The National Academies Press.
- National Research Council. 2010. *Managing University Intellectual Property in the Public Interest*. S. Merrill and A. Mazza, eds. Washington, DC: The National Academies Press.
- National Research Council. 2011. *Building the 21st Century: U.S.-China Cooperation on Science, Technology, and Innovation*. C. W. Wessner, rapporteur. Washington, DC: The National Academies Press.
- National Research Council. 2011. *Growing Innovation Clusters for American Prosperity*. C. W. Wessner, rapporteur. Washington, DC: The National Academies Press.
- National Research Council. 2011. *The Future of Photovoltaics Manufacturing in the United States*. C. W. Wessner, rapporteur. Washington, DC: The National Academies Press.
- National Research Council. 2012. *Building Hawaii's Innovation Economy*. C. W. Wessner, rapporteur. Washington, DC: The National Academies Press.
- National Research Council. 2012. *Building the Arkansas Innovation Economy*. C. W. Wessner, rapporteur. Washington, DC: The National Academies Press.
- National Research Council. 2012. *Building the U.S. Battery Industry for Electric-Drive Vehicles: Progress, Challenges, and Opportunities*. C. W. Wessner, rapporteur. Washington, DC: The National Academies Press.
- National Research Council. 2012. *Clustering for 21st Century Prosperity*. C. W. Wessner, rapporteur. Washington, DC: The National Academies Press.
- National Research Council. 2012. *Meeting Global Challenges: German-U.S. Innovation Policy*. C. W. Wessner, rapporteur. Washington, DC: The National Academies Press.
- National Research Council. 2012. *Rising to the Challenge: U.S. Innovation Policy for the Global Economy*. C. W. Wessner and A. W. Wolff, eds. Washington, DC: The National Academies Press.
- National Research Council. 2013. *Building the Illinois Innovation Economy: Summary of a Symposium*. C. W. Wessner, rapporteur. Washington, DC: The National Academies Press.
- National Research Council. 2013. *Building the Ohio Innovation Economy: Summary of a Symposium*. C. W. Wessner, rapporteur. Washington, DC: The National Academies Press.
- National Research Council. 2013. *Competing in the 21st Century: Best Practice in State and Regional Innovation Initiatives*. Washington, DC: The National Academies Press.
- National Research Council. 2013. *Strengthening American Manufacturing: The Role of the Manufacturing Extension Partnership—Summary of a Symposium*. C. W. Wessner, rapporteur. Washington, DC: The National Academies Press.
- National Research Council. 2014. *SBIR at the Department of Defense*. Washington, DC: The National Academies Press.
- National Research Council. 2014. *The Flexible Electronics Opportunity in 21st Century Manufacturing*. Washington, DC: The National Academies Press.

- National Science Board. 2005. *Science and Engineering Indicators 2005*. Arlington, VA: National Science Foundation.
- National Science Board. 2006. *Science and Engineering Indicators 2006*. Arlington, VA: National Science Foundation.
- National Science Foundation. 2004. "Federal R&D Funding by Budget Function: Fiscal Years 2003-2005" (historical tables). NSF 05-303. Arlington, VA: National Science Foundation.
- National Science Foundation. 2006. "SBIR/STTR Phase II Grantee Conference, Book of Abstracts." Office of Industrial Innovation. May 18-20, 2006. Louisville, Kentucky.
- National Science Foundation. "Committee of Visitors Reports and Annual Updates," <http://www.nsf.gov/eng/general/cov/>.
- National Science Foundation. "Emerging Technologies," <http://www.nsf.gov/eng/sbir/eo.jsp>.
- National Science Foundation. "Guidance for Reviewers," [http://www.eng.nsf.gov/sbir/peer\\_review.htm](http://www.eng.nsf.gov/sbir/peer_review.htm).
- National Science Foundation. "National Science Foundation at a Glance," <http://www.nsf.gov/about>.
- National Science Foundation. National Science Foundation Manual 14, *NSF Conflicts of Interest and Standards of Ethical Conduct*, [http://www.eng.nsf.gov/sbir/COI\\_Form.doc](http://www.eng.nsf.gov/sbir/COI_Form.doc).
- National Science Foundation. 2006. "SBIR/STTR Phase II Grantee Conference, Book of Abstracts." Office of Industrial Innovation. May 18-20, 2006, Louisville, Kentucky.
- National Science Foundation. 2006. "News Items from the Past Year." Press Release. April 10.
- National Science Foundation, Office of Industrial Innovation. 2005. Draft Strategic Plan. June 2.
- National Science Foundation, Office of Legislative and Public Affairs. 2003. SBIR Success Story from News Tip. Web's "Best Meta-Search Engine." March 20.
- Nelson, R. R. 1982. *Government and Technological Progress*. New York: Pergamon.
- Nelson, R. R. 1986. "Institutions Supporting Technical Advances in Industry." *American Economic Review, Papers and Proceedings* 76(2):188.
- Nelson, R. R., ed. 1993. *National Innovation System: A Comparative Study*. New York: Oxford University Press.
- Office of Management and Budget. 1996. "Economic Analysis of Federal Regulations under Executive Order 12866."
- Office of Management and Budget. 2004. "What Constitutes Strong Evidence of Program Effectiveness," [http://www.whitehouse.gov/omb/part/2004\\_program\\_eval.pdf](http://www.whitehouse.gov/omb/part/2004_program_eval.pdf).
- Office of the President. 1990. *U.S. Technology Policy*. Washington, DC: Executive Office of the President.
- Organisation for Economic Co-operation and Development. 1982. *Innovation in Small and Medium Firms*. Paris: Organisation for Economic Co-operation and Development.
- Organisation for Economic Co-operation and Development. 1995. *Venture Capital in OECD Countries*. Paris: Organisation for Economic Co-operation and Development.
- Organisation for Economic Co-operation and Development. 1997. *Small Business Job Creation and Growth: Facts, Obstacles, and Best Practices*. Paris: Organisation for Economic Co-operation and Development.
- Organisation for Economic Co-operation and Development. 1998. *Technology, Productivity and Job Creation: Toward Best Policy Practice*. Paris: Organisation for Economic Co-operation and Development.
- Organisation for Economic Co-operation and Development. 2006. "Evaluation of SME Policies and Programs: Draft OECD Handbook." *OECD Handbook*. CFE/SME 17. Paris: Organisation for Economic Co-operation and Development.
- Perko, J. S., and F. Narin. 1997. "The Transfer of Public Science to Patented Technology: A Case Study in Agricultural Science." *Journal of Technology Transfer* 22(3):65-72.
- Perret, G. 1989. *A Country Made by War: From the Revolution to Vietnam—The Story of America's Rise to Power*. New York: Random House.
- Poland, C. A., R. Duffin, I. Kinloch, A. Maynard, W. A. H. Wallace, A. Seaton, V. Stone, and S. Brown. 2008. "Carbon Nanotubes Introduced into the Abdominal Cavity of Mice Show Asbestos-like Pathogenicity in a Pilot Study." *Nature Nanotechnology* 3(7):423.

- Porter, M. E. 1998. "Clusters and Competition: New Agendas for Government and Institutions." In M. E. Porter, ed. *On Competition*. Boston, MA: Harvard Business School Press.
- Powell, W. W., and P. Brantley. 1992. "Competitive Cooperation in Biotechnology: Learning through Networks?" In N. Nohria and R. G. Eccles, eds. *Networks and Organizations: Structure, Form and Action*. Boston, MA: Harvard Business School Press. Pp. 366-394.
- Price Waterhouse. 1985. *Survey of Small High-tech Businesses Shows Federal SBIR Awards Spurring Job Growth, Commercial Sales*. Washington, DC: Small Business High Technology Institute.
- Reid, G. C., and J. A. Smith. 2007. *Risk Appraisal and Venture Capital in High Technology New Ventures*. New York: Routledge.
- Roberts, E. B. 1968. "Entrepreneurship and Technology." *Research Management* (July):249-266.
- Rogelberg, S., C. Spitzmüller, I. Little, and S. Reeve. 2006. "Understanding Response Behavior to an Online Special Survey Topics Organizational Satisfaction Survey." *Personnel Psychology* 59:903-923.
- Romer, P. 1990. "Endogenous Technological Change." *Journal of Political Economy* 98:71-102.
- Rosa, P., and A. Dawson. 2006. "Gender and the Commercialization of University Science: Academic Founders of Spinout Companies." *Entrepreneurship & Regional Development* 18(4):341-366. July.
- Rosenberg, N. 1969. "The Direction of Technological Change: Inducement Mechanisms and Focusing Devices." *Economic Development and Cultural Change* 18:1-24.
- Rosenbloom, R., and W. Spencer. 1996. *Engines of Innovation: U.S. Industrial Research at the End of an Era*. Boston, MA: Harvard Business School Press.
- Rubenstein, A. H. 1958. *Problems Financing New Research-Based Enterprises in New England*. Boston, MA: Federal Reserve Bank.
- Ruegg, R., and I. Feller. 2003. *A Toolkit for Evaluating Public R&D Investment Models, Methods, and Findings from ATP's First Decade*. NIST GCR 03-857.
- Ruegg, R., and P. Thomas. 2007. *Linkages from DoE's Vehicle Technologies R&D in Advanced Energy Storage to Hybrid Electric Vehicles, Plug-in Hybrid Electric Vehicles, and Electric Vehicles*. Washington, DC: U.S. Department of Energy/Office of Energy Efficiency and Renewable Energy.
- Sahlman, W. A. 1990. "The Structure and Governance of Venture Capital Organizations." *Journal of Financial Economics* 27:473-521.
- Saxenian, A. 1994. *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Cambridge, MA: Harvard University Press.
- Schacht, W. H. 2008. "The Small Business Innovation Research (SBIR) Program: Reauthorization Efforts." Congressional Research Service, Library of Congress.
- Scherer, F. M. 1970. *Industrial Market Structure and Economic Performance*. New York: Rand McNally College Publishing.
- Schumpeter, J. 1950. *Capitalism, Socialism, and Democracy*. New York: Harper and Row.
- Scotchmer, S. 2004. *Innovation and Incentives*. Cambridge MA: MIT Press.
- Scott, J. T. 1998. "Financing and Leveraging Public/Private Partnerships: The Hurdle-lowering Auction." *STI Review* 23:67-84.
- Scott, J. T. 2000. "An Assessment of the Small Business Innovation Research Program in New England: Fast Track Compared with Non-Fast Track." In National Research Council. *The Small Business Innovation Research Program: An Assessment of the Department of Defense Fast Track Initiative*. Washington, DC: National Academy Press.
- Sheehan, K. 2001. "E-mail Survey Response Rates: A Review." *Journal of Computer Mediated Communication* 6(2).
- Siegel, D., D. Waldman, and A. Link. 2004. "Toward a Model of the Effective Transfer of Scientific Knowledge from Academicians to Practitioners: Qualitative Evidence from the Commercialization of University Technologies." *Journal of Engineering and Technology Management* 21(1-2).
- Silverstein, S. C., H. H. Garrison, and S. J. Heinig. 1995. "A Few Basic Economic Facts about Research in the Medical and Related Life Sciences." *FASEB* 9:833-840.

- Society for Prevention Research. 2004. *Standards of Evidence: Criteria for Efficacy, Effectiveness and Dissemination*. <http://www.preventionresearch.org/softtext.php>.
- Sohl, J., J. Freear, and W. E. Wetzel Jr. 2002. "Angles on Angels: Financing Technology-Based Ventures—An Historical Perspective." *Venture Capital: An International Journal of Entrepreneurial Finance* 4(4).
- Solow, R. S. 1957. "Technical Change and the Aggregate Production Function." *Review of Economics and Statistics* 39:312-320.
- Stiglitz, J. E., and A. Weiss. 1981. "Credit Rationing in Markets with Incomplete Information." *American Economic Review* 71:393-409.
- Stokes, D. E. 1997. *Pasteur's Quadrant: Basic Science and Technological Innovation*. Washington, DC: The Brookings Institution.
- Stowsky, J. 1996. "Politics and Policy: The Technology Reinvestment Program and the Dilemmas of Dual Use." Mimeo. University of California.
- Tassey, G. 1997. *The Economics of R&D Policy*. Westport, CT: Quorum Books.
- Thurber, K. J. 2011. *Big Wave Surfing*. Edina, MN: Beaver Pond Press.
- Tibbetts, R. 1997. "The Role of Small Firms in Developing and Commercializing New Scientific Instrumentation: Lessons from the U.S. Small Business Innovation Research Program." In J. Irvine, B. Martin, D. Griffiths, and R. Gathier, eds. *Equipping Science for the 21st Century*. Cheltenham UK: Edward Elgar Press.
- Tirman, J. 1984. *The Militarization of High Technology*. Cambridge, MA: Ballinger.
- Tyson, L., T. Petrin, and H. Rogers. 1994. "Promoting Entrepreneurship in Eastern Europe." *Small Business Economics* 6:165-184.
- University of New Hampshire Center for Venture Research. 2007. *The Angel Market in 2006*, <http://wsbe2.unh.edu/files/Full%20Year%202006%20Analysis%20Report%20-%20March%202007.pdf>.
- U.S. Congress, House Committee on Science, Space, and Technology. 1992. *SBIR and Commercialization: Hearing Before the Subcommittee on Technology and Competitiveness of the House Committee on Science, Space, and Technology, on the Small Business Innovation Research [SBIR] Program*. Testimony of James A. Block, President of Creare, Inc. Pp. 356-361.
- U.S. Congress. House Committee on Science, Space, and Technology. 1992. *The Small Business Research and Development Enhancement Act of 1992*. House Report (REPT. 102-554) Part I (Committee on Small Business).
- U.S. Congress. House Committee on Science, Space, and Technology. 1998. *Unlocking Our Future: Toward a New National Science Policy: A Report to Congress by the House Committee on Science, Space, and Technology*. Washington, DC: Government Printing Office. <http://www.access.gpo.gov/congress/house/science/cp105-b/science105b.pdf>.
- U.S. Congress. House Committee on Small Business. Subcommittee on Workforce, Empowerment, and Government Programs. 2005. *The Small Business Innovation Research Program: Opening Doors to New Technology*. Testimony by Joseph Hennessey. 109th Cong., 1st sess., November 8.
- U.S. Congress. House Committee on Science, Space, and Technology. Subcommittee on Technology and Innovation. 2007. Hearing on "Small Business Innovation Research Authorization on the 25th Program Anniversary." Testimony by Robert Schmidt. April 26.
- U.S. Congress. Senate Committee on Small Business. 1981. Small Business Research Act of 1981. S.R. 194, 97th Congress.
- U.S. Congress. Senate Committee on Small Business. 1999. Senate Report 106-330. *Small Business Innovation Research (SBIR) Program*. August 4. Washington, DC: U.S. Government Printing Office.
- U.S. Congress. Senate Committee on Small Business. 1999. Senate Report 106-330. *Small Business Innovation Research (SBIR) Program*. August 4. Washington, DC: U.S. Government Printing Office.

- U.S. Congress. Senate Committee on Small Business. 2006. *Strengthening the Participation of Small Businesses in Federal Contracting and Innovation Research Programs*. Testimony by Michael Squillante. 109th Cong., 2nd sess., July 12.
- U.S. Congressional Budget Office. 1985. *Federal Financial Support for High-technology Industries*. Washington, DC: U.S. Congressional Budget Office.
- U.S. Department of Education. 2005. "Scientificity-Based Evaluation Methods: Notice of Final Priority." *Federal Register* 70(15):3586-3589.
- U.S. Food and Drug Administration. 1981. Protecting Human Subjects: Untrue Statements in Application. 21 C.F.R. §314.12.
- U.S. Food and Drug Administration. "Critical Path Initiative," <http://www.fda.gov/oc/initiatives/criticalpath/>.
- U.S. General Accounting Office. 1987. *Federal Research: Small Business Innovation Research participants give program high marks*. Washington, DC: U.S. General Accounting Office.
- U.S. General Accounting Office. 1989. *Federal Research: Assessment of Small Business Innovation Research Program*. Washington, DC: U.S. General Accounting Office.
- U.S. General Accounting Office. 1992. *Federal Research: Small Business Innovation Research Program Shows Success but Can Be Strengthened*. RCED-92-32. Washington, DC: U.S. General Accounting Office.
- U.S. General Accounting Office. 1997. *Federal Research: DoD's Small Business Innovation Research Program*. RCED-97-122, Washington, DC: U.S. General Accounting Office.
- U.S. General Accounting Office. 1998. *Federal Research: Observations on the Small Business Innovation Research Program*. RCED-98-132. Washington, DC: U.S. General Accounting Office.
- U.S. General Accounting Office. 1999. *Federal Research: Evaluations of Small Business Innovation Research Can Be Strengthened*. RCED-99-198. Washington, DC: U.S. General Accounting Office.
- U.S. Government Accountability Office. 2006. *Small Business Innovation Research: Agencies Need to Strengthen Efforts to Improve the Completeness, Consistency, and Accuracy of Awards Data*. GAO-07-38. Washington, DC: U.S. Government Accountability Office.
- U.S. Government Accountability Office. 2006. *Small Business Innovation Research: Information on Awards Made by NIH and DoD in Fiscal years 2001-2004*. GAO-06-565. Washington, DC: U.S. Government Accountability Office.
- U.S. Public Law 106-554, Appendix I-H.R. 5667—Section 108.
- U.S. Small Business Administration. 1992. *Results of Three-Year Commercialization Study of the SBIR Program*. Washington, DC: U.S. Government Printing Office.
- U.S. Small Business Administration. 1994. *Small Business Innovation Development Act: Tenth-Year Results*. Washington, DC: U.S. Government Printing Office.
- U.S. Small Business Administration. 1998. "An Analysis of the Distribution of SBIR Awards by States, 1983-1996." Washington, DC: Small Business Administration.
- U.S. Small Business Administration. 2003. "Small Business by the Numbers." SBA Office of Advocacy. May.
- U.S. Small Business Administration. 2006. *Frequently Asked Questions*, June 2006. <http://www.sba.gov/advo/stats/sbfaq.pdf>.
- U.S. Small Business Administration. 2006. "Small Business by the Numbers." SBA Office of Advocacy. May.
- Venture Economics. 1988. *Exiting Venture Capital Investments*. Wellesley, MA: Venture Economics.
- Venture Economics. 1996. "Special Report: Rose-colored Asset Class." *Venture Capital Journal* 36 (July):32-34.
- VentureOne. 1997. National Venture Capital Association 1996 annual report. San Francisco: VentureOne.
- Wallsten, S. J. 1996. "The Small Business Innovation Research Program: Encouraging Technological Innovation and Commercialization in Small Firms." Unpublished working paper. Stanford University.

- Wallsten, S. J. 1998. "Rethinking the Small Business Innovation Research Program." In L. M. Branscomb and J. Keller, eds. *Investing In Innovation*. Cambridge, MA: MIT Press.
- Washington Technology. 2007. "Top 100 Federal Prime Contractors: 2004." May 14.
- Weiss, S. 2006. "The Private Equity Continuum." Presentation at the Executive Seminar on Angel Funding, University of California at Riverside, December 8-9, Palm Springs, CA.
- Yu, M-F., O. Lourie, M. J. Dyer, K. Moloni, T. F. Kelly, and R. S. Ruoff. 2000. "Strength and Breaking Mechanism of Multiwalled Carbon Nanotubes Under Tensile Load. *Science* 287(5453):637-640.